CERTIFICATION

I, Kenichi Hori, being duly qualified to translate from the Japanese language to the English language, hereby certify that I have translated the attached document, Japanese Patent Application No. 2000-294172, filed in the Japanese Patent Office September 27, 2000, from the Japanese to the English language, and that the attached document is a true and correct translation of said Japanese document.

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[DOCUMENT NAME] SPECIFICATION

[TITLE OF THE INVENTION] PRINTING UP TO EDGES OF PRINTING PAPER WITHOUT PLATEN SOILING

[SCOPE OF CLAIM FOR PATENT]

[Claim 1] A dot-recording device for recording ink dots on a surface of a print medium with the aid of a dot-recording head provided with a plurality of dot-forming elements for ejecting ink droplets, the dot-recording device comprising:

a main scanning unit configured to drive the dot-recording head and/or the print medium to perform main scanning;

a head driver configured to drive at least some of the dot-forming elements to form dots during the main scanning;

a platen configured to extend in the main scanning direction and to be disposed opposite the plurality of dot-forming elements at least along part of a main scan path, and the platen being configured to support the print medium at a position opposite the dot-recording head;

a sub-scanning unit configured to move the print medium to perform sub-scanning in between the main scans; and

a controller configured to control the dot recording device, and wherein the platen comprising:

a first support configured to support the print medium, the first support extending in the main scanning direction at a position opposite a first sub-group of dot-forming elements selected from the plurality of dot-forming elements;

a first slot extending in the main scanning direction at a position opposite a second sub-group of dot-forming elements which are disposed in the sub-scanning direction downstream from the first sub-group of dot-forming elements;

a second support configured to support the print medium, the second support extending in the main scanning direction at a position opposite a third

sub-group of dot-forming elements which are disposed in the sub-scanning direction downstream from the second sub-group of dot-forming elements; and

a second slot extending in the main scanning direction at a position opposite a fourth sub-group of dot-forming elements which are disposed in the sub-scanning direction downstream from the third sub-group of dot-forming elements.

[Claim 2] A dot-recording device as defined in Claim 1, wherein the controller has:

a first controller for forming dots on the print medium with the aid of the second to fourth sub-groups of dot-forming elements without the use of the first sub-group of dot-forming elements in a first image-printing mode where printing images without blank spaces up to front and/or rear edges of the print medium; and

a second controller for forming dots on the print medium with the aid of the first to fourth sub-groups of dot-forming elements in a second image-printing mode where printing mages with blank spaces along the front and rear edges of the print medium.

[Claim 3] A dot-recording device as defined in Claim 2, wherein a surface area of the print medium is divided into an upper-edge portion containing the front edge of the print medium, a lower-edge portion containing the rear edge of the print medium, and an intermediate portion disposed between the upper-edge portion and lower-edge portion, wherein the controller further has:

an upper-edge printing unit for forming dots in the upper-edge portion of the print medium with the aid of the fourth sub-group of dot-forming elements without the use of any of the first to third sub-groups of dot-forming elements;

an intermediate printing unit for forming dots in the intermediate portion of the print medium with the aid of the second to fourth sub-groups of dot-forming elements without the use of the first sub-group of dot-forming elements; and

a lower-edge printing unit for forming dots in the lower-edge portion of the

print medium with the aid of the second sub-group of dot-forming elements without the use of the first, third, or fourth sub-group of dot-forming elements.

[Claim 4] A dot-recording device as defined in Claim 2 or 3, wherein the dot-recording head includes a plurality of dot-forming element groups for ejecting different types of ink, the plurality of dot-forming element groups being aligned in the main scanning direction, and wherein

the first slot is a single slot provided opposite the second sub-groups of dot-forming elements selected; and

the second slot is a single slot provided opposite the fourth sub-groups of dot-forming elements.

[Claim 5] A dot-recording method using a dot-recording device for recording ink dots on a surface of a print medium supported by a platen, the dot-recording device including a dot-recording head having groups of dot-forming elements consisting of a plurality of dot-forming elements for ejecting ink droplets, the method forming dots by driving at least part of the plurality of dot-forming element while performing main-scanning by driving at least one of the dot-recording head or the print medium, and performing sub-scanning by driving the print medium in the direction perpendicular to the main-scanning direction in the intervals between the main-scanning; wherein the platen comprises:

a first support configured to support the print medium, the first support extending in the main scanning direction at a position opposite a first sub-group of dot-forming elements selected from the plurality of dot-forming elements;

a first slot extending in the main scanning direction at a position opposite a second sub-group of dot-forming elements which are disposed in the sub-scanning direction downstream from the first sub-group of dot-forming elements;

a second support configured to support the print medium, the second support extending in the main scanning direction at a position opposite a third

sub-group of dot-forming elements which are disposed in the sub-scanning direction downstream from the second sub-group of dot-forming elements; and

a second slot extending in the main scanning direction at a position opposite a fourth sub-group of dot-forming elements which are disposed in the sub-scanning direction downstream from the third sub-group of dot-forming elements, wherein the dot-recording method comprises:

(a) a step of preparing a first image-printing mode for printing images without blank spaces up to front and/or rear edges of the print medium, and a second image-printing mode for printing images with blank spaces along the front and rear edges of the print medium;

(b) a step of forming dots on a print medium with the aid of the second to fourth sub-groups of dot-forming elements without the use of the first sub-group of dot-forming elements in accordance with the first image-printing mode; and

(c) a step of forming dots on the print medium with the aid of the first to fourth sub-groups of dot-forming elements in accordance with the second image-printing mode.

[Claim 6] A dot-recording method as defined in Claim 5, wherein the step (b) comprises:

(b1) a step of forming dots in the upper-edge portion of the print medium with the aid of the fourth sub-group of dot-forming elements without the use of any of the first to third sub-groups of dot-forming elements;

(b2) a step of forming dots in the intermediate portion of the print medium with the aid of the second to fourth sub-groups of dot-forming elements without the use of the first sub-group of dot-forming elements; and

(b3) a step of forming dots in the lower-edge portion of the print medium with the aid of the second sub-group of dot-forming elements without the use of the first, third, or fourth sub-group of dot-forming elements.

[Claim 7] A computer readable medium for storing a computer program product for causing a computer, the computer equipped with a dot-recording

device for recording ink dots on a surface of a print medium supported by a platen, the dot-recording device including a dot-recording head having groups of dot-forming elements consisting of a plurality of dot-forming elements for ejecting ink droplets, to form dots on the print medium by driving at least part of the plurality of dot-forming element while performing main-scanning by driving at least one of the dot-recording head or the print medium, and performing sub-scanning by driving the print medium in the direction perpendicular to the main-scanning direction in the intervals between the main-scanning, wherein the platen comprising:

a first support configured to support the print medium, the first support extending in the main scanning direction at a position opposite a first sub-group of dot-forming elements selected from the plurality of dot-forming elements;

a first slot extending in the main scanning direction at a position opposite a second sub-group of dot-forming elements which are disposed in the sub-scanning direction downstream from the first sub-group of dot-forming elements;

a second support configured to support the print medium, the second support extending in the main scanning direction at a position opposite a third sub-group of dot-forming elements which are disposed in the sub-scanning direction downstream from the second sub-group of dot-forming elements; and

a second slot extending in the main scanning direction at a position opposite a fourth sub-group of dot-forming elements which are disposed in the sub-scanning direction downstream from the third sub-group of dot-forming elements, the computer readable medium comprising:

a computer program for causing the computer to form dots on the print medium with the aid of the second to fourth sub-groups of dot-forming elements without the use of the first sub-group of dot-forming elements in a first image-printing mode where printing images without blank spaces up to front and/or rear edges of the print medium, and for causing the computer to form dots

on the print medium with the aid of the first to fourth sub-groups of dot-forming elements in a second image-printing mode where printing mages with blank spaces along the front and rear edges of the print medium.

[DETAILED DESCIPTION OF THE INVENTION]

[0001]

[Field of the Invention]

The present invention relates to a technique for recording dots on the surface of a recording medium with the aid of a dot-recording head, and more particularly to a technique for printing images up to the edges of printing paper without soiling the platen.

[0002]

[Description of the Prior Art]

Printers in which ink is ejected from the nozzles of a print head have recently become popular as computer output devices. Fig. 30 is a side view depicting the periphery of a print head for a conventional printer. Printing paper P is supported on a platen 26o while facing the head 28o. The printing paper P is fed in the direction of arrow A by the upstream paper feed rollers 25p and 25q disposed upstream of the platen 26o and by the downstream paper peed rollers 25r and 25s disposed downstream of the platen 26o. Dots are recorded and images printed on the printing paper P when ink is ejected from the head.

[0003]

[Problems to be solved by the Invention]

When an attempt is made to print images up to the edges of printing paper with the aid of such a printer, it is necessary to arrange the printing paper such that the edges of the printing paper are disposed underneath the print head (that is, on the platen) and to cause ink droplets to be ejected from the print head. With such printing, however, the ink droplets sometimes miss the edges of the printing paper (for which the droplets have been originally intended) and end up depositing on the platen due to errors developing during the feeding of the

printing paper, a shift in the impact location of the ink droplets, or the like. In such cases, the ink deposited on the platen soils the printing paper transported over the platen in the next step.

[0004]

It is an object of the present invention, which was perfected in order to overcome the above-described shortcomings of the prior art, to provide a technique that allows images to be printed up to the edges of printing paper while preventing ink droplets from depositing on the platen.

[0005]

[Means for Solving the Problem and its Function/Effect]

Perfected in order to at least partially overcome the above-described shortcomings, the present invention envisages performing specific procedures for a dot-recording device designed to record dots on the surface of a print medium with the aid of a dot-recording head provided with a plurality of dot-forming elements for ejecting ink droplets. The platen of this printer comprises a first support, a first slot and a second support. The dot-recording device comprises: a main scanning unit configured to drive the dot-recording head and/or the print medium to perform main scanning; a head driver configured to drive at least some of the dot-forming elements to form dots during the main scanning; a platen configured to extend in the main scanning direction and to be disposed opposite the dot-forming elements at least along part of a main scan path, and the platen being configured to support the print medium at a position opposite the dot-recording head; a sub-scanning unit configured to move the print medium to perform sub-scanning sub-scanning in between the main scans; and a controller configured to control the dot recording device.

[0006]

The platen of this printer comprises a first support, a first slot and a second support. The first support supports the print medium and extends in the main scanning direction at a position opposite a first sub-group of dot-forming

elements selected from the plurality of dot-forming elements. The first slot extends in the main scanning direction at a position opposite a second sub-group of dot-forming elements which are disposed in the sub-scanning direction downstream from the first sub-group of dot-forming elements. The second support supports the print medium and extends in the main scanning direction at a position opposite a third sub-group of dot-forming elements which are disposed in the sub-scanning direction downstream from the second sub-group of dot-forming elements. The platen of this printer may further comprise a second slot. The second slot extends in the main scanning direction at a position opposite a fourth sub-group of dot-forming elements which are disposed in the sub-scanning direction downstream from the third sub-group of dot-forming elements.

[0007]

Adopting such an embodiment allows the upper-edge portion of the print medium, which is fed over the platen from the upstream side (in the course of sub-scanning), to be supported on the first support. It is therefore unlikely that the upper-edge portion (front-edge portion) will fall into the first slot during sub-scanning. It is also possible to print images without blank spaces all the way to the edges of the print medium with the aid of the second sub-group of dot-forming elements (disposed opposite the first slot) and/or the third sub-group of dot-forming elements (disposed opposite the second slot).

[0008]

The printing (dot-forming) procedure performed by such a printing device entails forming dots on a print medium with the aid of the second to fourth sub-groups of dot-forming elements without the use of the first sub-group of dot-forming elements in accordance with a first image-printing mode for printing images without blank spaces up to the front and/or rear edges of the print medium. The printing procedure also entails forming dots on the print medium with the aid of the first to fourth sub-groups of dot-forming elements in

accordance with a second image-printing mode for printing images with blank spaces along the front and rear edges of the print medium. Adopting such an embodiment makes it possible to prevent ink droplets from depositing on the platen and to print images without blank spaces along the edges of the print medium with the aid of dot-forming elements disposed opposite the slots in accordance with the first image-printing mode. Images can be printed faster with the second image-printing mode than with the first image-printing mode because the first sub-group of dot-forming elements is used in addition to the dot-forming elements involved in performing the first image-printing mode.

[0009]

Assuming that the surface area of the print medium is divided into an upper-edge portion containing the front edge of the print medium, a lower-edge portion containing the rear edge of the print medium, and an intermediate portion disposed between the upper-edge portion and lower-edge portion, the following embodiment is preferable. In the upper-edge portion of the print medium, dots are formed with the aid of the fourth sub-group of dot-forming elements without the use of any of the first to third sub-groups of dot-forming elements. In the intermediate portion of the print medium, dots are formed with the aid of the second to fourth sub-groups of dot-forming elements without the use of the first sub-group of dot-forming elements. In the lower-edge portion of the print medium, dots are formed with the aid of the second sub-group of dot-forming elements without the use of the first, third, or fourth sub-group of dot-forming elements. As used herein, the term "using sub-groups of dot-forming elements" refers to the partial use of at least some of the dot-forming elements when an image is printed. The term "a sub-group of dot-forming elements is left unused" refers to the fact that none of the dot-forming elements belonging to this sub-group of dot-forming elements is used even once when an image is printed.

[0010]

Because this embodiment entails using the fourth sub-group of dot-forming

elements to print images in the upper-edge portion of the print medium, ink droplets are directed to the second slot, and the platen supports are prevented from being soiled when the ink droplets thus ejected miss the upper-edge portion. Similarly, using the second sub-group of dot-forming elements to print images in the lower-edge portion allows ink droplets to be directed to the first slot and prevents platen supports from being soiled when the ink droplets miss the lower-edge portion. It is therefore possible to prevent platen supports from being soiled and to form dots all the way to the front and rear edges of the print medium. Fast printing can be achieved for the intermediate portion because of the use of the second to fourth sub-groups of dot-forming elements.

[0011]

In the case that the dot-recording device is such that the dot-recording head is aligned in the main scanning direction and provided with a plurality of dot-forming element groups for ejecting different types of ink, the following embodiment is preferable. The first slot is a single slot provided opposite the second sub-groups of dot-forming elements selected from the plurality of dot-forming element groups. The second slot is a single slot provided opposite the fourth sub-groups of dot-forming elements selected from the plurality of dot-forming element groups. Adopting such an embodiment allows dots to be formed using different types of ink in accordance with the first image-printing mode.

[0012]

The present invention can be implemented as the following embodiments.

(1) A dot-recording method, print control method, or printing method.

(2) A dot-recording device, print control device, or printing device.

(3) A computer program for operating the device or implementing the method.

(4) A storage medium containing computer programs for operating the device or implementing the method.

(5) A data signal carried by a carrier wave and designed to contain a computer

program for operating the device or implementing the method.

[0013]

[Description of the Preferred Embodiments]

Embodiments of the present invention will now be described through embodiments in the following sequence.

A. Overview of Embodiments

B. First Embodiment

B1. Device Structure

B2. Selection of Image-printing Mode

B3. Feeding in the Course of Sub-scanning Before Start of Printing

B4. Feeding in the Course of Sub-scanning During Printing

C. Second Embodiment

D. Modifications

D1. Modification 1

D2. Modification 2

D3. Modification 3

D4. Modification 4

D5. Modification 5

[0014]

A. Overview of Embodiments

Fig. 1 is a side view depicting the structure of the periphery of a print head for an ink-jet printer configured according to an embodiment of the present invention. A platen 26 of the printer comprises, in order from the upstream side in the sub-scanning direction, an upstream support 26sf, an upstream slot 26f, a central support 26c, and a downstream slot 26r. The printer has a first image-printing mode for printing images without blank spaces all the way to the lower and upper edges of printing paper, and a second image-printing mode for printing images in the regular manner, with blank spaces formed along the upper and lower edges of the printing paper during printing. The second

image-printing mode is performed using all the nozzles (nozzle Nos. 1–11 from nozzle groups Nr, Ni, Nh, and Nf) of the print head 28 throughout the entire process of printing images on printing paper. By contrast, the first image-printing mode is performed using solely nozzle Nos. 1–8 (nozzle groups Nr, Ni, and Nh) of the print head 28.

[0015]

In the first image-printing mode, the upper-edge portion Pf of the printing paper P is disposed above the downstream slot 26r when images are printed along the upper (front) edge Pf of the printing paper P. The images in the upper-edge portion are printed by nozzle Nos. 1 and 2 (nozzle group Nr), which are located above the downstream slot 26r. The images in the intermediate portion of the printing paper P are printed by nozzle Nos. 1–8 (nozzle groups Nr, Ni, and Nh). The lower edge of the printing paper P is disposed above the upstream slot 26f when images are printed along the lower (back) edge of the printing paper P. The printing is accomplished using nozzle Nos. 8 and 9 (nozzle group Nh), which are located above the upstream slot 26f.

[0016]

In the embodiment shown in Fig. 1, the platen 26 is comprising the upstream support 26sf disposed further upstream from the upstream slot 26f. For this reason, the printing paper P is supported at two points by the upstream paper feed rollers 25a and 25b and the upstream support 26sf when initially transported by the upstream paper feed rollers 25a and 25b. The front-edge portion Pf of the printing paper P is therefore fed in the direction of the central support 26c while kept in a relatively horizontal position. The resulting advantage is that the front edge Pf of the printing paper P is unlikely to fall into the upstream slot 26f during initial feeding in the course of sub-scanning.

[0017]

The nozzle group Nr disposed above the downstream slot 26r is used when images are printed in the upper-edge portion of the printing paper P, and

the nozzle group Nh disposed above the upstream slot 26f is used when images are printed in the lower-edge portion. The images can therefore be printed without blank spaces all the way to the upper and lower edges of the printing paper while the platen 26 is prevented from being soiled. Faster printing can be achieved in the intermediate portion because images are printed in this portion with the aid of the nozzle group Nr, the nozzle group Nh, and the interposed nozzle group Ni. Chronologically, images are printed first by the downstream portion of the nozzle group Nr; then by the nozzle groups Nr, Ni, and Nh; and finally by the upstream portion of the nozzle group Nh. In other words, the nozzles used for printing are smoothly shifted in the sub-scanning direction from the downstream side to the upstream side. The resulting advantage is that high-quality printing results can be obtained without the need to reverse the direction in which printing paper is fed during sub-scanning.

[0018]

B. First Embodiment

B1. Device Structure

Fig. 2 is a block diagram depicting the structure of the software for the present printing device. In the computer 90, an application program 95 is executed within the framework of a specific operating system. The operating system contains a video driver 91 or a printer driver 96, and the application program 95 outputs the image data D to be transferred to the printer 22 by means of these drivers. The application program 95 for performing video retouching or the like allows images to be read from the scanner 12 and displayed by the CRT 21 by means of the video driver 91 while processed in a prescribed manner. The data ORG presented by the scanner 12 are in the form of primary-color image data ORG obtained by reading a color original and composed of the following three color components: red (R), green (G), and blue (B).

[0019]

When the application program 95 generates a printing command in response to instruction input through mouse 13 or keyboard, the printer driver 96 of the computer 90 receives image data from the application program 95, and the resulting data are converted to a signal that can be processed by the printer 22 (in this case, into a signal containing multiple values related to the colors cyan, magenta, light cyan, light magenta, yellow, and black). In the example shown in Fig. 2, the printer driver 96 comprises a resolution conversion module 97, a color correction module 98, a halftone module 99, and a rasterizer 100. A color correction table LUT and a dot-forming pattern table DT are also stored.

[0020]

The role of the resolution conversion module 97 is to convert the resolution of the color image data handled by the application program 95 (that is, the number of pixels per unit length) into a resolution that can be handled by the printer driver 96. Because the image data converted in terms of resolution in this manner are still in the form of video information composed of three colors (RGB), the color correction module 98 converts these data into the data for each of the colors (cyan (C), magenta (M), light cyan (LC), light magenta (LM), yellow (Y), and black (K)) used by the printer 22 for individual pixels while the color correction table LUT is consulted.

[0021]

The color-corrected data have a gray scale with 256 steps, for example. The halftone module 99 executes a halftone routine for expressing this gray scale in the printer 22 by forming dispersed dots. The halftone module 99 executes the halftone routine upon specifying the dot formation patterns of the corresponding ink dots in accordance with the gray scale of the image data by consulting the dot-forming pattern table DT. The image data thus processed are sorted according to the data sequence to be transferred to the printer 22 by the rasterizer 100, and are outputted as final print data PD. The print data PD contain information about the amount of feed in the sub-scanning direction and

information about the condition of dot recording during each main scan. In the present embodiment, the sole role of the printer 22 is to form ink dots in accordance with the print data PD without processing the images, although it is apparent that such processing can also be carried out by the printer 22.

[0022]

The overall structure of the printer 22 will now be described with reference to Z. As can be seen in the drawing, the printer 22 comprises a mechanism for transporting paper P with the aid of a paper feed motor 23; a mechanism for reciprocating a carriage 31 in the axial direction of the sliding shaft 34 with the aid of a carriage motor 24; a mechanism for actuating the print head 28 mounted on the carriage 31 and ejecting the ink to form ink dots; and a control circuit 40 for exchanging signals between the paper feed motor 23, the carriage motor 24, the print head 28, and a control panel 32.

[0023]

The mechanism for reciprocating the carriage 31 in the axial direction of the platen 26 comprises a sliding shaft 34 mounted perpendicular to the direction of transport of the printing paper P and designed to slidably support the carriage 31, a pulley 38 for extending an endless drive belt 36 from the carriage motor 24, a position sensor 39 for sensing the original position of the carriage 31, and the like.

[0024]

The carriage 31 can support a cartridge 71 for black ink (K) and a color-ink cartridge 72 containing inks of the following six colors: cyan (C), light cyan (LC), magenta (M), light magenta (LM), and yellow (Y). A total of six ink-ejecting heads 61 to 66 are formed in the print head 28 in the bottom portion of the carriage 31. Mounting the cartridge 71 for the black (K) ink and the cartridge 72 for the color inks on the carriage 31 allows the ink to be fed from the ink cartridges to the ejection heads 61 to 66.

[0025]

Fig. 4 is a diagram depicting the arrangement of the ink-jet nozzles N in the ink-ejecting head 28. These nozzles form six nozzle arrays for ejecting the ink of each color (black (K), cyan (C), light cyan (LC), magenta (M), light magenta (LM), and yellow (Y)), and the 48 nozzles of each array form a single row at a constant pitch k. These six nozzle arrays are aligned in the main scanning direction. More specifically, the nozzle pairs for each nozzle array lie on the same main scan lines. These nozzle arrays (rows of nozzles) correspond to the dot-forming elements. Nozzle pitch is a value equal to the number of raster lines (that is, pixels) accommodated by the interval between the nozzles on the print heads in the sub-scanning direction. For example, nozzles whose intervals correspond to three interposed raster lines have a pitch k of 4. As used herein, the term "raster line " refers to a row of pixels aligned in the main scanning direction. The term "pixel" refers to a single square of an imaginary grid formed on a print medium (and occasionally beyond the edges of the print medium) in order to define the positions at which dots are recorded by the deposition of ink droplets. Fig. 4 generally shows the position of each nozzle and does not exactly illustrate the size of head or the number of nozzles.

[0026]

The nozzles of each nozzle array are divided into four subgroups in order from the upstream side in the sub-scanning direction. The subgroups correspond to the sub-groups of dot-forming elements. The subgroups of each nozzle array will be collectively referred to hereinbelow as "nozzle groups Nf, Nh, Ni, and Nr," indicated in order from the upstream side in the sub-scanning direction. The first nozzle group Nf, which is disposed on the most upstream side, corresponds to the first sub-group of dot-forming elements, and the second nozzle group Nh corresponds to the second sub-group of dot-forming elements. The third nozzle group Ni corresponds to the third sub-group of dot-forming elements, and the fourth nozzle group Nr corresponds to the fourth sub-group of dot-forming elements. Here, the sub-groups of dot-forming elements of each

nozzle array are collectively treated as nozzle groups Nf, Nh, Ni, and Nr. These nozzle groups are selected to correspond to the slots, supports, and other structural components of the platen 26, which is disposed facing the print head 28 during main scanning. The correspondence between the nozzle groups and the slots, supports, and other structural components of the platen 26 will be described below.

[0027]

Fig. 5 is a plan view depicting the periphery of the platen 26. The width of the platen 26 in the sub-scanning direction is greater than the maximum width of the printing paper P. Upstream paper feed rollers 25a and 25b are provided upstream of the platen 26. Whereas the upstream paper feed roller 25a is a single drive roller, the upstream paper feed roller 25b comprises a plurality of freely rotating small rollers. Downstream paper feed rollers 25c and 25d are also provided downstream of the platen. The downstream paper feed roller 25c comprises a plurality of rollers on a drive shaft, and the downstream paper feed roller 25d comprises a plurality of freely rotating small rollers. The downstream paper feed roller 25d has radial teeth (portions between slots) in the external peripheral surface thereof and appears to be shaped as a gear when viewed in the direction of the axis of rotation. The downstream paper feed roller 25d is commonly referred to as a milled roller and is designed to press the printing paper P against the platen 26. The downstream paper feed roller 25c and upstream paper feed roller 25a rotate synchronously at the same peripheral speed.

[0028]

The print head 28 moves back and forth in the main scanning direction over the platen 26 sandwiched between the upstream paper feed rollers 25a and 25b and the downstream paper feed rollers 25c and 25d. The printing paper P is held by the upstream paper feed rollers 25a and 25b and the downstream paper feed rollers 25c and 25d, and an intermediate portion thereof is supported

by the upper surface of the platen 26 while disposed opposite the rows of nozzles in the print head 28. The paper is fed in the sub-scanning direction by the upstream paper feed rollers 25a and 25b and the downstream paper feed rollers 25c and 25d, and images are sequentially recorded by the ink ejected from the nozzles of the print head 28.

[0029]

The platen 26 is provided with an upstream slot 26f and a downstream slot 26r, which are located on the upstream and downstream sides, respectively, in the sub-scanning direction. The width of the upstream slot 26f or downstream slot 26r in the main scanning direction is greater than the maximum width of the printing paper P that can be accommodated by the printer 22. In addition, absorbent members 27f and 27r for accepting and absorbing ink droplets Ip are disposed in the bottom portions of these slots 26f and 26r, respectively. The portion of the platen further upstream of the upstream slot 26f is referred to as "a upstream support 26sf." The portion between the upstream slot 26f and downstream slot 26r of the platen 26 is referred to as "a central support 26c." The portion of the platen further downstream of the downstream slot 26r is referred to as "a downstream support 26sr." The upstream slot 26f corresponds to the first slot, and the downstream slot 26r corresponds to the second slot. The upstream support 26sf corresponds to the first support, and the central support 26c corresponds to the second support.

[0030]

A description will now be given in order from the upstream side in the sub-scanning direction. First, the upstream support 26sf is provided such that it extends in the main scanning direction at a position opposite the first nozzle group Nf, which belongs to the nozzles of the print head 28 and is disposed on the most upstream side. The upstream support 26sf is provided with a flat upper surface. The upstream slot 26f is then provided such that it extends in the main scanning direction at a position opposite the second nozzle group Nh,

which is disposed downstream of the first nozzle group Nf. The central support 26c is provided such that it extends in the main scanning direction at a position opposite the third nozzle group Ni, which is disposed downstream of the second nozzle group Nh. The downstream slot 26r is then provided such that it extends in the main scanning direction at a position opposite the fourth nozzle group Nr, which is disposed downstream of the third nozzle group Ni. Finally, the downstream support 26sr is provided such that it extends in the main scanning direction at a position in the sub-scanning direction downstream from those nozzles of the print head 28 that are disposed at the downstream edge in the sub-scanning direction. In the print head 28 depicted in Fig. 5, the nozzle groups Nf, Nh, Ni, and Nr are hatched with oblique lines at mutually different inclines and intervals.

[0031]

The inner structure of the control circuit 40 (see Fig. 3) belonging to the printer 22 will now be described. The control circuit 40 contains the following units in addition to CPU 41, PROM 42, and RAM 43: a PC interface 45 for exchanging data with the computer 90, a drive buffer 44 for outputting the ON and OFF signals of the ink jet to the ink-ejecting heads 61–66, and the like. These elements and circuits are connected together by a bus. The control circuit 40 receives the dot data processed by the computer 90, temporarily stores them in the RAM 43, and outputs the results to the drive buffer 44 according to specific timing.

[0032]

In the printer 22 thus configured, the carriage 31 is reciprocated by the carriage motor 24 while paper P is transported by the paper feed motor 23, the piezoelement of each of the nozzle units belonging to the print head 28 is actuated at the same time, ink droplets Ip of each color are ejected, and ink dots are formed to produce multicolored images on the paper P.

[0033]

In the first image-printing mode as described below, the areas near the top and lower edges of printing paper are printed differently from the intermediate area of the printing paper because the upper edge Pf of the printing paper P is printed over the downstream slot 26r, and the lower edge Pr is printed over the upstream slot 26f. In the present specification, the routine whereby images are printed in the intermediate area of printing paper will be referred to as an "intermediate routine," the routine whereby images are printed in the area near the upper edge of printing paper will be referred to as an "upper-edge routine," and the routine whereby images are printed in the area near the lower edge of printing paper will be referred to as a "lower-edge routine." In addition, when referring both the upper-edge routine and lower-edge routine, they will be referred to as an "upper- or lower-edge routine".

[0034]

The width of the upstream slot 26f and downstream slot 26r in the sub-scanning direction can be expressed as follows.

[0035]

$W = p \times n + \alpha$

[0036]

In the formula, p is a single feed increment in the sub-scanning direction during a top- or lower-edge routine, n is the number of feed increments in the sub-scanning direction during a top- or lower-edge routine, and α is an estimated feed error in the sub-scanning direction during a top- or lower-edge routine. The α-value of the lower-edge routine (upstream slot 26f) should preferably be set to a level above that of the α-value for a upper-edge routine (downstream slot 26r). Specifying the slot width of the platen according to this formula makes it possible to provide the slots with a width sufficient to adequately receive the ink droplets ejected from the nozzles during a top- or lower-edge routine.

[0037]

B2. Selection of Image-printing Mode

Fig. 6 is a flowchart depicting the sequence of printing routines. The printer 22 has a first image-printing mode for printing images without blank spaces at the upper and lower edges of a printing paper P, and a second image-printing mode for printing images with blank spaces at the upper and lower edges of the printing paper P. When operated in the second image-printing mode, the printer 22 prints images with the aid of the nozzles belonging to all the nozzle groups, whereas operating the printer in the first image-printing mode entails printing images solely by means of the second nozzle group Nh and the third nozzle groups Ni and Nr, which are positioned downstream from the second nozzle group Nh in the sub-scanning direction. As used herein, the phrase "nozzles are used" refers to the fact that the nozzles can be used as needed. At least some of the nozzles belonging to the nozzle groups should therefore be used, and some of the other nozzles may sometimes be left unused, depending on the image data involved in the printing process.

[0038]

The user first selects either the first or second image-printing mode for printing. Selection information about the image-printing mode is specified for an application 95 through a keyboard 14, mouse 13, or other input device connected to a computer 90 (see Fig. 2). The application 95 or printer driver 96 prepares print data PD in accordance with the image-printing mode thus selected.

[0039]

Fig. 7 is a plan view depicting the relation between image data D and printing paper P in the first image-printing mode. In the first image-printing mode, the present embodiment is such that image data D are provided up to the area outside the printing paper P beyond the upper edge Pf of the printing paper P. For the same reasons, the area facing the lower edge is also treated such that image data D are provided up to the area outside the printing paper P

beyond the lower edge Pr of the printing paper P. The present embodiment is therefore such that the relation between the image data D and the size of the printing paper P, on the one hand, and the image data D and the arrangement of the printing paper P during printing, on the other hand, assumes the configuration shown in Fig. 7.

[0040]

In the present specification, the terms "upper edge (portion)" and "lower edge (portion)" are used to designate the edges of the printing paper P corresponding to the top and bottom of the image data recorded on the printing paper P, and the terms "front edge (portion)" and "rear edge (portion)" are used to designate the edges of the printing paper P corresponding to the direction in which the printing paper P is advanced during sub-scanning in the printer 22. In the present specification, the term "upper edge (portion)" corresponds to the front edge (portion) of the printing paper P, and the term "lower edge (portion)" corresponds to the rear edge (portion).

[0041]

Fig. 8 is a plan view depicting the relation between the image data D2 and printing paper in the second image-printing mode. The image data D2 for the second image-printing mode is used to form images in an area smaller than the printing paper P, as can be seen in Fig. 8. The images are printed on the printing paper P while blank spaces are left along the upper, lower, left, and right edges.

[0042]

B3. Feeding in the Course of Sub-scanning Before Start of Printing

Fig. 9 is a diagram depicting the manner in which the front edge Pf of a sheet of printing paper P is transported over a platen 26. For the sake of simplicity, the description will be given on the assumption that a single nozzle row comprises 11 nozzles. Here, nozzle Nos. 1 and 2 of each nozzle array constitute a fourth nozzle group Nr, and nozzle Nos. 3–6 constitute a third nozzle

group Ni. Nozzle Nos. 7 and 8 constitute a second nozzle group Nh, and nozzle Nos. 9–11 constitute a first nozzle group Nf.

[0043]

The front-edge portion Pf of a printing paper P is supported by the upstream support 26sf when the paper is first fed in the course of sub-scanning by the upstream paper feed rollers 25a and 25b over the platen 26. The front-edge portion Pf then passes over the upstream slot 26f and reaches a point above the central support 26c, as shown in Fig. 7. The front-edge portion Pf passes over the central support 26c and reaches a point above the downstream slot 26r. With the first image-printing mode, the feeding in the sub-scanning direction is stopped at this point, and ejection of ink droplets is started. In other words, the upper-edge routine is started. Feeding in the sub-scanning direction is sometimes stopped and ink droplets are ejected before the front edge Pf reaches the downstream slot 26r if the number of raster lines for the portion (see Fig. 10) established beyond the front edge Pf of the printing paper P exceeds a certain limit in relation to the image data. With the second image-printing mode, ejection of ink droplets starts after the front edge Pf is seized between the downstream paper feed rollers 25c and 25d.

[0044]

In the embodiment shown in Fig. 9, the printing paper P is supported on the upstream support 26sf after being delivered by the upstream paper feed rollers 25a and 25b. The printing paper P is supported at least at two points by the upstream paper feed rollers 25a and 25b and the upstream support 26sf, and the portion in front of the upstream paper feed rollers 25a and 25b maintains constant orientation when the front-edge portion Pf of the printing paper P passes above the upstream slot 26f. It is therefore unlikely that the front-edge portion Pf will fall into the upstream slot 26f.

[0045]

The upstream support 26sf faces the first nozzle group Nf and has a specific length Rsf in the sub-scanning direction. The printing paper P is therefore supported over a specific distance by the upstream paper feed rollers 25a and 25b and the upstream support 26sf, which has a specific length in the sub-scanning direction. Consequently, the portion of the printing paper P in front of the upstream paper feed rollers 25a and 25b can consistently maintain constant orientation, and the front-edge portion Pf is unlikely to fall into the upstream slot 26f.

[0046]

The upstream support 26sf has a flat upper surface, and the printing paper P assumes a shape close to that of the upper surface of the flat upstream support 26sf under the action of gravity when the paper is on the upstream support 26sf. Consequently, at this point as well, the portion of the printing paper P in front of the upstream paper feed rollers 25a and 25b has a substantially flat shape, and the front-edge portion Pf is unlikely to fall into the upstream slot 26f.

[0047]

Fig. 10 is a diagram showing a case in which the front-edge portion Pf of a sheet of printing paper P reaches a point above the platen 26 of a printer pertaining to a comparative example. The printer of the first embodiment was provided with an upstream support 26sf at a position opposite the area extending up to the most upstream nozzle No. 11 from nozzle No. 9. In the printer shown in Fig. 10, however, an upstream slot 26fc1 is provided at a position opposite the most upstream nozzle Nos. 11 and 10, and a portion is provided for supporting the printing paper P. A section 26sc1 of the platen 26 extends to the upstream side of the upstream slot 26fc1. All the other features are the same as in the first embodiment.

[0048]

The printer of the comparative example is configured such that the section 26sc1 of the platen 26 is disposed further upstream from the print head 28, as are the upstream paper feed rollers 25a and 25b for supporting the printing paper P; and the interval between them is less than in the first embodiment. Adopting such an embodiment makes it more likely that the front-edge portion Pf of the printing paper P will fall into the upstream slot 26fo when the paper is first fed by the upstream paper feed rollers 25a and 25b over the platen 26 in the course of sub-scanning. In addition, the front-edge portion Pf is apt to fall into the upstream slot 26fo when the printing paper P is in the form of curved roll paper with a convex shape. The front-edge portion Pf is less likely to fall into the upstream slot 26fo if the section 26sc1 of the platen 26 has sufficient length in the sub-scanning direction on the upstream side, but adopting such an embodiment increases printer dimensions in the sub-scanning direction.

[0049]

B4. Feeding in the Course of Sub-scanning During Printing

The first and second image-printing modes employ different patterns of feeding the system in the course of sub-scanning during printing. Whereas the first image-printing mode entails performing different feed patterns for sub-scanning in the upper-edge routine, intermediate routine, and lower-edge routine, the second image-printing mode is performed using the same feed patterns for sub-scanning. Such feeding in the course of sub-scanning is described below separately for the upper-edge and intermediate routines of the first image-printing mode, the lower-edge routine of the first image-printing mode, and the second image-printing mode.

[0050]

(1) Upper-edge Routine and Intermediate Routine of First Image-printing Mode

Fig. 11 is a diagram depicting the manner in which raster lines are recorded by particular nozzles in an area near the upper edge (tip) of printing paper. For the sake of simplicity, the description will be limited to a single row

of nozzles. A single row of nozzles consists of 11 nozzles spaced at 3-raster line intervals. The eight nozzles disposed on the downstream side in the sub-scanning direction are the only nozzles used in the first image-printing mode, however. In Fig. 11, only the eight nozzles participating in the printing operation are shown, with nonparticipating nozzles omitted from the drawing.

[0051]

In Fig. 11, a single vertical column of squares represents the print head 28. The numerals 1–8 in each square indicate nozzle numbers. In the present specification, "No." is attached to these numbers to indicate each nozzle. In Fig. 11, the print head 28, which is transported over time in relative fashion in the sub-scanning direction, is shown moving in sequence from left to right. In the drawings, the nozzles within bold boxes are used for recording dots on raster lines.

[0052]

During the upper-edge routine, the single-dot incremental feeding in the sub-scanning direction is repeated seven times, as shown in Fig. 11. This upper-edge routine involves printing images in accordance with the first recording mode. As a unit of feed increment in the sub-scanning direction, the term "dot" designates a single-dot pitch corresponding to the printing resolution in the sub-scanning direction, and this dot is also equal to raster line pitch.

[0053]

The operation then proceeds to the intermediate routine and the 5-, 2-, 3-, and 6- dot feed increments are repeated in the order indicated. The intermediate routine involves printing images in accordance with the second recording mode. The system in which sub-scanning is performed by combining different feed increments in this manner is referred to as "non-constant feeding."

[0054]

Such feeding in the sub-scanning direction allows each raster line (with the exception of some raster lines) to be recorded by two nozzles. In the

example shown in Fig. 11, the fifth raster line from the top is recorded by nozzle Nos. 1 and 2. In the process, nozzle No. 2 may, for example, record pixels with even-numbered addresses, and nozzle No. 1 may record pixels with odd-numbered addresses. In addition, the ninth raster line from the top will be recorded by nozzle Nos. 2 and 3. The system in which the pixels within a single raster line are printed by a plurality of nozzles in distributed fashion in this manner will be referred to as "overlap printing." With such overlap printing, the dots of a single raster line are recorded by a plurality of nozzles passing over this raster line during a plurality of main scans for which the positions of printing paper in the sub-scanning direction are mutually different in relation to the print head.

[0055]

In Fig. 11, the four raster lines from the uppermost tier are such that the nozzle No. 1 makes only one pass per main scan during printing. The result is that pixels cannot be distributed between, and printed by, two nozzles for these raster lines. Consequently, it is assumed with reference to the present embodiment that these four raster lines cannot be used to record images in the first image-printing mode. Specifically, it is assumed with reference to the present embodiment that only the fifth and greater raster lines, as counted from the upstream edge in the sub-scanning direction, can be considered as the raster lines on which the nozzles of the print head 28 can form dots in order to record images. The raster line area in which images can be recorded in this manner is referred to as a printable area. In addition, the raster line area in which image cannot be recorded is referred to as a nonprintable area. In Fig. 11, the numbers attached in order from top to the raster lines in which dots can be recorded by the nozzles of the print head 28 are indicated on the left side of the drawing. The same applies hereinbelow to the drawings illustrating the recording of dots during the upper-edge routine.

[0056]

In Fig. 11, three or more nozzles pass over the 13^{th} to 15^{th} raster lines from the top in the course of a main scan during printing. In the raster lines covered by three or more nozzles during printing, dots are recorded only by two of the nozzles involved. For these raster lines, the preferred practice is to record dots as much as possible with the nozzles that pass over the raster lines after the operation has entered the intermediate routine. With the intermediate routine, non-constant feeding is accomplished, and various combinations are created from the nozzles passing over mutually adjacent raster lines, making it possible to expect that the printing operation will yield better image quality than that yielded by the upper-edge routine, which is characterized by constant feeding in single-dot increments.

[0057]

As a result of such printing, the area from the fifth to the eighth raster line (as counted from the uppermost raster line on which dots can be recorded by the print head) is recorded solely by nozzle Nos. 1 and 2 (fourth nozzle group Nr). The ninth and greater raster lines are recorded using Nos. 1–8 (nozzle groups Nr, Ni, and Nh). The relation between these raster lines and the printing paper P, and the effect thereof, will be described below.

[0058]

In the first image-printing mode, images can be recorded without blank spaces up to the upper edge of the printing paper. As described above, the present embodiment is such that images can be recorded by selecting the fifth and greater raster lines (printable area), as counted from the upstream edge in the sub-scanning direction, from among the raster lines on which dots can be recorded by the nozzles of the print head 28. Consequently, images could theoretically be recorded very close to the upper edge of printing paper by starting dot recording after the printing paper is positioned relative to the print head 28 such that the fifth raster line (as counted from the upper edge) is disposed exactly at the position occupied by the upper edge of the printing paper.

There are, however, cases in which the feed increment errors occur during feeding in the sub-scanning direction. There are also cases in which the direction in which ink droplets are ejected shifts away as a result of a manufacturing error or another factor related to the print head. The formation of blank spaces along the upper edge of the printing paper should preferably be prevented in cases in which the position at which the ink droplets are ejected on the printing paper is shifted for these reasons. It is thus assumed with reference to the first image-printing mode that the image data D used for printing are provided starting from the fifth raster line, which is counted from the upstream edge in the sub-scanning direction and is selected from the raster lines on which dots can be recorded by the nozzles of the print head 28, and that printing is started from a state in which the upper edge of the printing paper P assumes the position occupied by the seventh raster line, as counted from the upstream edge in the sub-scanning direction. Consequently, the prescribed position occupied by the upper edge of the printing paper in relation to each raster line during the start of printing coincides with the position occupied by the seventh raster line, as counted from the upstream edge in the sub-scanning direction (Fig. 11). In the first image-printing mode, two raster lines are selected for the width (see Fig. 7) of the portion of image data D provided up to the area outside the printing paper P beyond the upper edge Pf of the printing paper P. Similarly, two raster lines are selected for the width of the portion of image data D provided up to the area outside the printing paper P beyond the lower edge Pr of the printing paper P. The raster lines disposed along the lower edge will be described below.

[0059]

Fig. 12 is a side view depicting the relation between the print head 28 and the printing paper P at the start of printing. Here, the central support 26c of the platen 26 is provided within a range R26 that extends from an upstream position corresponding to two raster lines (as counted from nozzle No. 2 of the print head

28) to a downstream position corresponding to two raster lines (as counted from nozzle No. 7). The upstream slot 26f is provided within a range that extends from a downstream position corresponding to a single raster line (as counted from nozzle No. 7) to an upstream position corresponding to two raster lines (as counted from nozzle No. 8). The downstream slot 26r is provided within a range that extends from a downstream position corresponding to two raster lines (as counted from nozzle No. 1) to an upstream position corresponding to two raster lines (as counted from nozzle No. 2). Consequently, the ink droplets Ip from nozzle Nos. 1 and 2 land in the downstream slot 26r, and the ink droplets from nozzle Nos. 7 and 8 land in the downstream slot 26r when the ink droplets are ejected from the nozzles in the absence of printing paper. In other words, the ink droplets from these nozzles are prevented from depositing on the central support 26c of the platen 26. In Fig. 12, nozzle Nos. 9–11, which are left unused according to the first image-printing mode, are shown as black dots.

[0060]

The fourth nozzle group Nr, which is shown above in Figs. 4 and 5, is composed of nozzle Nos. 1 and 2 shown in Fig. 12. The downstream slot 26r (see Fig. 5) is disposed underneath the portion passed over by these nozzles during main scanning. Printing is started when the upper edge Pf of the printing paper P reaches the position above the downstream slot 26r shown by the solid line in Fig. 12.

[0061]

As described above, the upper edge Pf of the printing paper P reaches the position of the seventh raster line (as counted from the upstream edge in the sub-scanning direction), which is one of the raster lines on which dots are recorded by the nozzles of the print head 28. Specifically, it follows from Fig. 12 that the upper edge of the printing paper P reaches a rearward position corresponding to six raster lines, as counted from nozzle No. 1. The broken lines in Fig. 12 indicate the prescribed positions of raster lines based on image

data. If it is assumed that printing starts at this position, then the raster line belonging to the uppermost tier of the printable area (fifth raster line from the top in Fig. 11) is supposed to be recorded by nozzle No. 2, but the printing paper P has not yet reached the area underneath nozzle No. 2. The result is that accurate feeding of the printing paper P by the upstream paper feed rollers 25a and 25b will allow the ink droplets Ip ejected by nozzle No. 2 to descend directly into the downstream slot 26r. In addition, the raster line belonging to the uppermost tier of the printable area will also be recorded by nozzle No. 1 following four single-dot feed increments, as shown in Fig. 11. Similarly, the printing paper P has not yet reached the area underneath nozzle No. 1 by the time four single-dot feed increments are completed. The result is that the ink droplets Ip ejected from nozzle No. 1 at this time descend directly into the downstream slot 26r. The same applies to recording the second raster line from the top of the printable area (sixth raster line from the top in Fig. 11).

[0062]

There are also cases in which the upper edge of the printing paper P reaches the position occupied by the second raster line from the top of the printable area or by the raster line disposed in the uppermost tier of the printable area if the feed increment of the printing paper P exceeds the designed increment for any reason. The first image-printing mode is configured such that nozzle Nos. 1 and 2 are still capable of ejecting ink droplets Ip to cover the aforementioned raster lines in such cases, making it possible to record images along the upper edge of the printing paper P and to prevent blank spaces from forming. Specifically, blank spaces can be prevented from forming along the upper edge of the printing paper P when the feed increment of the printing paper P exceeds the designed increment but the excessive feed increment is still no more than two raster lines, as shown by the dashed line in Fig. 12.

[0063]

Another possibility is that the feed increment of the printing paper P falls short of the designed increment for any reason. In such cases the printing paper fails to arrive at the designated position, and the ink droplets Ip end up depositing on the underlying structure. In the first image-printing mode, the two raster lines along the intended upper-edge position of the paper sheet are recorded by nozzle Nos. 1 and 2, as shown in Fig. 11. A downstream slot 26r is disposed underneath these nozzles, so the ink droplets Ip descend into the downstream slot 26r and are absorbed by an absorbent member 27r if they fail to deposit on the printing paper P. It is thus possible to prevent situations in which the ink droplets Ip deposit on the upper surface of the platen 26 and subsequently soil the printing paper. Specifically, adopting the first image-printing mode makes it possible to prevent situations in which the ink droplets Ip deposit on the upper surface of the platen 26 and subsequently soil the printing paper P when the upper edge Pf of the printing paper P moves past the intended position of the upper edge during the start of printing but the deviation of the paper from the intended position of the upper edge is still no more than two raster lines.

[0064]

The above-described results can be obtained by adopting an arrangement in which ink droplets are ejected from at least some of the nozzles belonging to the fourth nozzle group Nr (fourth sub-group of dot-forming elements), and dots are formed on a sheet of printing paper P when the upper edge of the printing paper P passes above the opening of the downstream slot 26r during the printing of images along the upper edge of the printing paper P.

[0065]

The printing paper P should be held and fed in the sub-scanning direction by two groups of rollers composed of the upstream paper feed rollers 25a and 25b and the downstream paper feed rollers 25c and 25d. The reason is that this arrangement allows paper to be fed in the sub-scanning direction with higher

accuracy than when the sheet is held and fed in the sub-scanning direction by a single roller. However, the printing paper P is held and fed in the sub-scanning direction solely by the upstream paper feed rollers 25a and 25b when images are printed along the upper edge Pf of the printing paper. In the first image-printing mode, printing is started when the seventh raster line, as counted from the upstream edge in the sub-scanning direction and selected from raster lines on which dots can be recorded by the nozzles of the print head 28, reaches the position occupied by the upper edge Pf of the printing paper (see Figs. 11 and 12). Consequently, images are printed as the sheet is fed in the sub-scanning direction solely with the upstream paper feed rollers 25a and 25b from this position onward until the upper edge Pf of the printing paper is picked up by the downstream paper feed rollers 25c and 25d, that is, in the period during which the printing paper travels the distance L31, as shown in Fig. 12. In the first image-printing mode, where recording of the upper edge Pf is performed above the downstream slot 26r instead of the upstream slot 26f, the printing operation yields better image quality because the sheet is fed in the sub-scanning direction solely by the upstream paper feed rollers 25a and 25b, and the printing operation is completed in a comparatively short time. These effects are not limited to the above-described arrangement and extend to situations in which the area near the upper edge Pf of the printing paper is printed with nozzles located in the vicinity of the edge on the downstream side in the sub-scanning direction. This arrangement is particularly effective in cases in which the upstream drive units (upstream paper feed rollers 25a and 25b) for sub-scanning have comparatively low feed accuracy.

[0066]

The printing paper P is supported at three locations on the upstream support 26sf and central support 26c of the platen 26 and the upstream paper feed rollers 25a and 25b when images are printed on the area occupied by the upper edge. For this reason, the upper-edge portion of the printing paper P has

comparatively high resistance to downward bending when disposed above the downstream slot 26r. It is therefore less likely that the quality of printing in the upper-edge portion will be adversely affected by the bending of the printing paper.

[0067]

The printing of images in the upper-edge portion of the printing paper P by the fourth nozzle group Nr (nozzle Nos. 1 and 2) is done by a CPU 41 (see Fig. 3), as is the printing of images in the intermediate portion by the nozzle groups Nr, Ni, and Nh (nozzle Nos. 1–8). In other words, the CPU 41 functions as the upper-edge printing unit and intermediate printing unit. The upper-edge printing unit 41f and intermediate printing unit 41g are shown in Fig. 3 as functional units of the CPU 41.

[0068]

(2) Lower-edge Routine of First Image-printing Mode

Fig. 13 is a diagram depicting the manner in which raster lines are recorded by particular nozzles during the lower-edge routine. Fig. 13 depicts the results obtained from the moment an (n + 1)-*th* feed increment is completed in the sub-scanning direction until the moment the final (n + 17)-*th* feed increment is completed in the sub-scanning direction. In the first image-printing mode, the lower-edge routine entails performing the last nine (that is, from (n + 9)-*th* to (n + 17)-*th*) single-dot feed increments in the sub-scanning direction after 5-, 2-, 3- and 6-dot feed increment are repeatedly performed in sequence in the sub-scanning direction up to the (n + 8)-*th* cycle of the intermediate routine, as shown in Fig. 13. As a result, each of the raster lines (with the exception of some raster lines) aligned in the main scanning direction is recorded by two nozzles. In Fig. 13, the numbers attached in order from the bottom to the raster lines in which dots can be recorded by the nozzles of the print head 28 are indicated on the right side of the drawing. The rest is the same as in the drawings illustrating the recording of dots by the lower-edge routine.

[0069]

In Fig. 13, the four raster lines from the lowermost tier are such that nozzle No. 8 makes only one pass during printing. The fifth and greater raster lines above the lowermost tier are recorded by two or more nozzles. Consequently, the printable area of the portion occupied by the lower edge of the printing paper extends to the fifth and greater raster lines from the lowermost tier.

[0070]

In Fig. 13, three or more nozzles pass over the ninth and tenth raster lines from the bottom in the course of a main scan during printing. For the raster lines covered by three or more nozzles during printing, the preferred practice is to record dots with the nozzles that pass over the raster lines during an intermediate routine. The printing operation can be expected to yield better image quality than when a lower-edge routine is performed in single-dot constant feed increments.

[0071]

As a result of such printing, the area from the fifth to the tenth raster line (as counted from the lowermost raster line on which dots can be recorded by the print head) is recorded solely by nozzle Nos. 7 and 8 (second nozzle group Nh). The ninth and greater raster lines are recorded using Nos. 1–8 (nozzle groups Nr, Ni, and Nh). The relation between these raster lines and the printing paper P, and the effect thereof, will be described below.

[0072]

In the first image-printing mode, images can be recorded without blank spaces up to the lower edge in the same manner for the upper edge. As described above, the first image-printing mode is such that images can be recorded by selecting the fifth and greater raster lines (printable area), as counted from the downstream edge in the sub-scanning direction, from among the raster lines that can be used to record dots by the nozzles of the print head 28. It is assumed, however, that images are recorded on the printing paper

starting from the seventh raster line (as counted from the downstream edge in the sub-scanning direction) because of considerations related, among other things, to the feed increment errors that occur during feeding in the sub-scanning direction. Specifically, ink droplets Ip are ejected over the fifth and sixth raster lines, and the final main scan of the printing operation is performed in a state in which the lower edge of the printing paper is at a position corresponding to the seventh raster line, as counted from the upstream edge in the sub-scanning direction. Consequently, the intended position of the lower edge of the printing paper in relation to each raster line during the end of printing coincides with the position occupied by the seventh raster line, as counted from the downstream edge in the sub-scanning direction (Fig. 13).

[0073]

Fig. 14 is a plan view depicting the relation between the printing paper P and upstream slot 26f during printing in the lower-edge portion Pr of the printing paper P. In Fig. 14, the second nozzle group Nh in the hatched area of the print head 28 correspond to the area in which nozzle Nos. 7 and 8 are located. An upstream slot 26f is disposed underneath the area over which these nozzles pass during a main scan, and printing is completed when the lower edge Pr of the printing paper P reaches the position shown by the dashed line above the upstream slot 26f.

[0074]

Fig. 15 is a side view depicting the relation between the printing paper P and print head 28 during printing in the lower-edge portion Pr of the printing paper P. When images are printed in the lower-edge portion Pr of the printing paper P, the lower edge Pr of the printing paper P is disposed at the position occupied by the seventh raster line (as counted from the downstream edge in the sub-scanning direction), which is a raster line on which dots can be recorded by the nozzles of the print head 28, as described above (see Fig. 13). In other words, the lower edge of the printing paper P is disposed at a position six raster

lines in front of nozzle No. 8. The ink droplets Ip ejected from the nozzle Nos. 7 and 8 will therefore directly descend into the upstream slot 26f if it is assumed that dots are recorded in the lowermost tier of the printable area and on the second raster line from the lowermost tier (sixth and fifth raster lines from bottom in Fig. 13).

[0075]

If the feed increment of the printing paper P falls below the designed increment for any reason, nozzle Nos. 7 and 8 move beyond the lower edge Pr of the printing paper P and discharge ink droplets Ip for the designated raster lines (fifth and sixth raster lines from bottom in Fig. 13), making it possible to record images along the lower edge Pr of the printing paper P without leaving any blank spaces. Specifically, blank spaces can be prevented from forming along the lower edge of the printing paper P when the deficit of the feed increment is no more than two raster lines, as shown by the dashed line in Fig. 15.

[0076]

The four raster lines (seventh to tenth raster lines from bottom in Fig. 13) along the intended upper-edge position of the paper sheet are recorded by nozzle Nos. 7 and 8. It is therefore possible to prevent situations in which the ejected ink droplets Ip fall into the upstream slot 26f and deposit in the area occupied by the upper surface of the platen 26 when the feed increment of the printing paper P falls below the designed increment for any reason.

[0077]

The above-described results can be obtained by adopting an arrangement in which ink droplets are ejected from at least some of the nozzles belonging to the second nozzle group Nh (second sub-group of dot-forming elements), and dots are formed on a sheet of printing paper P when the lower edge of the printing paper P passes above the opening of the upstream slot 26f during the printing of images along the lower edge of the printing paper P. The

intermediate routine that precedes the lower-edge routine is also carried out using solely the second nozzle group Nh (nozzle Nos. 7 and 8), third nozzle group Ni (nozzle Nos. 3–6), and fourth nozzle group Nr (nozzle Nos. 1 and 2). In other words, the routine dispenses with the use of the first nozzle group Nf, which is disposed further upstream from the second nozzle group Nh used for the lower-edge routine. A transfer from the intermediate routine to the lower-edge routine can therefore be accomplished in a smoother manner than through the use of all the nozzles (nozzle Nos. 1–11), which include the first nozzle group Nf, during the intermediate routine.

[0078]

In the first image-printing mode, printing is completed when the seventh raster line, as counted from the downstream edge in the sub-scanning direction and selected from raster lines on which dots can be recorded by the nozzles of the print head 28, reaches the position occupied by the lower edge Pr of the printing paper (that is, a position two raster lines in front of nozzle No. 7 in Fig. 15) (see also Fig. 13). Consequently, images are printed as the sheet is fed in the sub-scanning direction solely with the downstream paper feed rollers 25c and 25d in the period during which the printing paper P travels the distance L41, which is the distance between the point at which the lower edge Pr of the printing paper P leaves the upstream paper feed rollers 25a and 25b, and the point shown in Fig. 15. In the first image-printing mode, where recording of the lower edge Pr is performed above the upstream slot 26f instead of the downstream slot 26r, the printing operation yields better image quality because the sheet is fed in the sub-scanning direction solely by the downstream paper feed rollers 25c and 25d, and the printing operation is completed in a comparatively short time. In particular, the downstream paper feed roller 25d is a gear-type roller, and the combined downstream paper feed rollers 25c and 25d can feed the sheet less accurately than can the upstream paper feed rollers 25a and 25b. For this reason, adopting an arrangement in which the sheet is fed in the

sub-scanning direction solely by the downstream paper feed rollers 25c and 25d and in which the printing operation is completed in a comparatively short time is highly effective for enhancing the quality of the final print. These effects are not limited to the above-described arrangement and extend to situations in which the area near the lower edge Pr of the printing paper is printed with nozzles located in the vicinity of the edge on the upstream side in the sub-scanning direction. This arrangement is particularly effective in cases in which the downstream drive units (downstream paper feed rollers 25c and 25d) for sub-scanning have comparatively low feed accuracy.

[0079]

The printing paper P is supported at three locations on the central support 26c and downstream support 26sr of the platen 26 and the downstream paper feed rollers 25c and 25d when images are printed on the area occupied by the lower edge. For this reason, the lower-edge portion of the printing paper P has comparatively high resistance to downward bending when disposed above the upstream slot 26f. It is therefore less likely that the quality of printing in the upper-edge portion will be adversely affected by the bending of the printing paper.

[0080]

The above-described printing of images in the lower-edge portion of the printing paper P by the second nozzle group Nh (nozzle Nos. 7 and 8) is done by a CPU 41 (see Fig. 3). In other words, the CPU 41 functions as the lower-edge printing unit. As described above, it is the CPU 41 that controls the units and allowing printing to be performed according to the first image-printing mode. In other words, the CPU 41 functions as the first image-printing unit. The first controller 41d and lower-edge printing unit 41h are shown in Fig. 3 as functional units of the CPU 41.

[0081]

(3) Second Image-printing Mode

Fig. 16 is a diagram depicting the manner in which raster lines are recorded by particular nozzles in accordance with the second image-printing mode. In the second image-printing mode (see Fig. 6), all the nozzles (Nos. 1–11) are employed. As used herein, the phrase "nozzles are used" refers to the fact that the nozzles can be used as needed. Consequently, some of the nozzles may be left unused with certain types of image data for printing.

[0082]

In the second image-printing mode, the system is alternately fed in 5- and 6-dot increments in the sub-scanning direction throughout the printing process, as can be seen in Fig. 16. As a result, the nonprintable areas formed along the upper and lower edges of the printing paper P are wider than those observed in the case of the first image-printing mode. For example, the nonprintable area along the upper edge extends across four raster lines from the upper edge in Fig. 11, as opposed to 35 raster lines in Fig. 16. The area (nonprintable area) extending across these 35 raster lines constitutes a blank space along the upper edge of the printing paper P, assuming that the position of the uppermost raster line on which dots can be recorded by nozzles is the imaginary position of the upper edge of paper.

[0083]

No particular restrictions are imposed on the nozzles for forming dots in the upper- and lower-edge portions of printable areas. With the second image-printing mode, in which images are printed while blank spaces are formed in the edge portions of the printing paper P, no inconvenience is encountered, however, because there is no need to print images near the upper or lower edge only by the nozzles (Nos. 1, 2, 7, and 8) above the slots. By contrast, the second image-printing mode is performed using all the nozzles (Nos. 1–11), allowing images to be printed faster than with the first image-printing mode, in which only a limited number of nozzles are used for printing.

[0084]

As described above, it is the CPU 41 that controls the units and allows printing to be performed according to the second image-printing mode. In other words, the CPU 41 functions as the second image-printing unit. The second controller 41e is shown in Fig. 3 as a functional unit of the CPU 41.

[0085]

C. Second Embodiment

Fig. 17 is a side view depicting the relation of a print head 28a with an upstream slot 26fa and a downstream slot 26ra according to a second embodiment. A description will now be given with reference to a case in which the number of nozzles and the method for recording each raster line are different from those employed in the first embodiment. In the second embodiment, a single nozzle row contains 13 nozzles. In the printing device used herein, the upstream support 26sf is disposed opposite nozzle Nos. 12 and 13 (first nozzle group Nfa) in the sub-scanning direction. The upstream slot 26fa is disposed opposite nozzle Nos. 9–11 (second nozzle group Nha). The central support 26ca is disposed opposite nozzle Nos. 4–8 (third nozzle group Nia). The downstream slot 26ra is disposed opposite nozzle Nos. 1–3 (fourth nozzle group Nra). The rest of the structure is the same as that of the printing device pertaining to the first embodiment.

[0086]

The first nozzle group Nfa of the second embodiment is an assembly corresponding to the first sub-group of dot-forming elements, and the second nozzle group Nha is an assembly corresponding to the second sub-group of dot-forming elements. The third nozzle group Nia is an assembly corresponding to the third sub-group of dot-forming elements, and the fourth nozzle group Nra is an assembly corresponding to the fourth sub-group of dot-forming elements.

[0087]

The second embodiment is performed without overlap printing. In other words, each raster line is recorded by a single nozzle in the course of a main scan. The nozzles employed for the first image-printing mode are nozzle Nos. 1–11 (nozzle groups Nra, Nia, and Nha), and the nozzles employed for the second image-printing mode are nozzle Nos. 1–13 (nozzle groups Nra, Nia, Nha, and Nfa).

[0088]

(1) Upper-edge Routine and Intermediate Routine of First Image-printing Mode

Figs. 18 and 19 are diagrams depicting the manner in which raster lines are recorded by particular nozzles in accordance with the upper-edge routine of the second embodiment. Figs. 18 and 19 depict two separate levels (upper and lower) of the process in which the head records the raster lines. The lower part of Fig. 18 is connected to the upper part of Fig. 19. The 38^{th} to 42^{nd} raster lines from the top are shown in overlapped form in Figs. 18 and 19.

[0089]

During the upper-edge routine of the second embodiment, 3-dot incremental feeding in the sub-scanning direction is repeated 11 times, as shown in Fig. 18. This upper-edge routine involves printing images in accordance with the first recording mode. The upper-edge routine is performed without the use of nozzles other than nozzle Nos. 1–3 (the fourth nozzle group Nra) of the print head 28a. In the drawings, the nozzles within bold boxes are used for recording dots on raster lines.

[0090]

Instead of an intermediate routine being performed immediately thereafter, a transitional routine is carried out prior to the intermediate routine. Similar to the upper-edge routine, the transitional routine involves repeating 3-dot feed increments four times in the sub-scanning direction. The nozzles (Nos. 1–11) (the fourth nozzle group Nra, Nia and Nha) are used in the transitional routine. The operation then proceeds to the intermediate routine, and constant 11-dot

feed increments are then repeated, as shown in Fig. 19. This intermediate routine involves printing images in accordance with the second recording mode.

[0091]

In Fig. 18, none of the nozzles pass over the second, third, or six raster line (as counted from the uppermost tier) during main-scan printing. It is therefore impossible to print pixels by connecting together adjacent raster lines selected from the raster lines extending from the uppermost tier to the sixth raster line. In the first image-printing mode, these six raster lines constitute a nonprintable area. For a raster line covered by two or more nozzles, such as the 13th to 16th raster lines from the top, it is assumed that dots are formed exclusively by the last nozzle passing over the raster line.

[0092]

In the second embodiment, images can be recorded by selecting the seventh and greater raster lines (printable area), as counted from the upstream edge in the sub-scanning direction, from among the raster lines on which dots can be recorded by the nozzles of the print head 28. The image data D used for printing are provided starting from the seventh raster line, as counted from the upstream edge in the sub-scanning direction. For the same reasons as those described with reference to the first embodiment, printing is started when the upper edge of the printing paper P reaches the position occupied by the 23rd raster line rather than the seventh raster line, as counted from the upstream edge in the sub-scanning direction. Specifically, the intended position of the upper edge of the printing paper P in relation to each raster line at the start of printing coincides with the position occupied by the 23rd raster line, as counted from the upstream edge in the sub-scanning direction (Fig. 18). Consequently, the second embodiment entails providing image data D for 16 raster lines, beyond the intended position of the upper edge of the printing paper P. For this reason, images can still be formed without blank spaces up to the upper edge of the printing paper P when an error affecting the feeding of the printing paper P

has occurred and the printing paper P is fed in an excessive manner, provided the error is within 16 raster lines.

[0093]

Another feature of the second embodiment is that nozzle Nos. 1–3 (the fourth nozzle group Nra) are the only nozzles involved in the recording of the 20 raster lines counted from the position occupied by the upper edge and the 16 preset raster lines extending beyond the intended position of the upper edge of the printing paper P. A downstream slot 26ra is disposed underneath nozzle Nos. 1–3. Ink droplets can therefore be prevented from depositing on a platen 26a when these droplets are ejected onto the 16 preset raster lines beyond the intended position of the upper edge of the printing paper P (that is, onto the area beyond the printing paper). It is also possible to prevent the ink droplets from depositing on the platen 26a when these droplets are ejected onto the raster lines in an area outside the upper-edge portion of the printing paper P in a state in which a feed error affecting the printing paper P has occurred and the printing paper P fails to arrive at the intended position, provided the feed error is within 20 raster lines.

[0094]

(2) Lower-edge Routine of Second Embodiment

Figs. 20 and 21 are diagrams depicting the manner in which raster lines are recorded by particular nozzles in accordance with the lower-edge routine of the second embodiment. The case shown in Fig. 20 involves (n + 1)-*th* and greater feed increments in the sub-scanning direction. Figs. 20 and 21 depict two separate levels (upper and lower) of the process in which the head records the raster lines. The lower part of Fig. 20 is connected to the upper part of Fig. 21. The 45th to 40th raster lines from the bottom are shown in overlapped form in Figs. 20 and 21.

[0095]

In the first image-printing mode, 3-dot feeding is repeated four times using the nozzles (Nos. 1–11) (the fourth nozzle group Nra, Nia and Nha) in accordance with a transitional routine after 11-dot constant feeding has been repeated in the sub-scanning direction from the (n + 1)-*th* cycle to the (n + 3)-*th* cycle in accordance with an intermediate routine, as shown in Figs. 20 and 21. Three-dot feeding is then performed using solely nozzle Nos. 9–11 in accordance with a lower-edge routine.

[0096]

In the second embodiment, images can be recorded by selecting the seventh and greater raster lines (printable area, counted from the bottom) from the raster lines on which dots can be recorded by the nozzles of the print head 28, as shown in Fig. 21. In the second embodiment, however, images are recorded using the eighth and greater raster lines from the bottom. In other words, the eighth and greater raster lines from the bottom in Fig. 21 constitute a printing area, and image data are specified for these raster lines.

[0097]

In Fig. 21, a raster linesuch as the 13^{th} or 16^{th} raster line from the bottom is covered by two or more nozzles during a main print scan. For a raster line covered by two or more nozzles during printing, dots are recorded by the last nozzle passing over the raster line.

[0098]

In the second embodiment, images can be recorded by selecting the eighth and greater raster lines, as counted from the downstream edge in the sub-scanning direction, from among the raster lines on which dots can be recorded by the nozzles of the print head 28. The image data D used for printing are provided starting from the eighth raster line. For the same reasons as those described with reference to the first embodiment, printing is completed when the lower edge of the printing paper P reaches the position occupied by the 38^{th} raster line rather than the eighth raster line, as counted from the

downstream edge in the sub-scanning direction. Specifically, the intended position of the lower edge of the printing paper P in relation to each raster line at the end of printing coincides with the position occupied by the 38^{th} raster line, as counted from the downstream edge in the sub-scanning direction (Fig. 21). Consequently, the second embodiment entails providing image data D equivalent to 30 raster lines, beyond the intended position of the lower edge of the printing paper P. For this reason, images can still be formed without blank spaces up to the lower edge when an error affecting the feeding of the printing paper P has occurred and the printing paper P fails to arrive at the intended position, provided the error is within 30 raster lines.

[0099]

Another feature of the second embodiment is that nozzle Nos. 9–11 (the second nozzle group Nha) are the only nozzles involved in the recording of the 20 upstream raster lines counted from the position occupied by the lower edge and the 30 preset raster lines extending beyond the intended position of the lower edge of the printing paper P. An upstream slot 26fa is disposed underneath nozzle Nos. 9–11. Ink droplets can therefore be prevented from depositing on a platen 26a when these droplets are ejected onto the preset raster lines beyond the intended position of the lower edge of the printing paper P (that is, onto the area beyond the printing paper). It is also possible to prevent the ink droplets from depositing on the platen 26a when these droplets are ejected onto the raster lines in an area outside the lower-edge portion of the printing paper P in a state in which a feed error affecting the printing paper P has occurred and the printing paper P is fed in an excessive manner, provided the feed error is within 20 raster lines.

[0100]

The printing paper P travels a longer distance when images are recorded in the area along the lower edge of the printing paper P than when images are recorded in the area along the upper edge of the printing paper P. It is highly

likely, therefore, that when images are recorded the area along the lower edge of the printing paper P is recorded, the positional error of the printing paper P will be greater than when images are recorded in the area along the upper edge of the printing paper P. In addition, the downstream paper feed roller 25d is a gear-type roller, and the combined downstream paper feed rollers 25c and 25d can feed the sheet with less accuracy than when the upstream paper feed rollers 25a and 25b are involved. This is another factor that increases the likelihood that the error created during the recording of the area along the lower edge will be greater than the positional error of the printing paper P created during the recording of the area along the upper edge. Consequently, the number of raster lines recorded solely by the nozzles (Nos. 9–11) (the second nozzle group Nha) above the upstream slot 26fa in the lower-edge portion of the printing paper P should preferably be set above the number of raster lines recorded solely by the nozzles (Nos. 1–3) (the fourth nozzle group Nra) above the downstream slot 26ra in the upper-edge portion of the printing paper P in the manner adopted in the second embodiment. For image data D, the number of raster lines selected for the area beyond the lower edge of the printing paper P should preferably be set above the number of raster lines selected for the area beyond the upper edge of the printing paper P.

[0101]

(3) Second Image-printing Mode

Fig. 22 is a diagram depicting the manner in which raster lines are recorded by particular nozzles in accordance with the second image-printing mode of the second embodiment. In the second image-printing mode, all the nozzles (Nos. 1–13 from nozzle groups Nra, Nia, Nha, and Nfa) are employed. In the second image-printing mode, the system is repeatedly fed in 13-dot increments in the sub-scanning direction throughout the printing process, as can be seen in Fig. 22. As a result, the nonprintable areas formed along the upper and lower edges of the printing paper P are wider than those observed in the

case of the first image-printing mode. For example, the nonprintable area along the upper edge extends across six raster lines from the upper edge in Fig. 18, as opposed to 36 raster lines in Fig. 22. The area (nonprintable area) extending across these 36 raster lines constitutes a blank space along the upper edge of the printing paper P, assuming that the position of the lowermost raster line on which dots can be recorded by nozzles is the imaginary position of the lower edge of paper. No particular restrictions are imposed on the nozzles for forming dots in the upper- and lower-edge portions of printable areas. The second image-printing mode is performed using all the nozzles (Nos. 1–13), allowing images to be printed faster than with the first image-printing mode, in which only a limited number of nozzles are used for printing.

[0102]

D. Modifications

The present invention is not limited by the above-described embodiments or embodiments and can be implemented in a variety of ways as long as the essence thereof is not compromised. For example, the following modifications are possible.

[0103]

D1. Modification 1

In the first embodiment, a downstream slot 26r is disposed underneath nozzle Nos. 1 and 2, and images are printed in the upper-edge portion by nozzle Nos. 1 and 2 in accordance with a first image-printing mode. The second embodiment is similar in the sense that images are printed in the upper-edge portion by nozzle Nos. 1–3, which are disposed above the slot. However, this arrangement is not the only possible option for the relation between the downstream slot and the nozzles for printing images in the upper-edge portion of printing paper. The embodiment in which each nozzle row has 48 nozzles may, for example, be configured such that a downstream slot is disposed underneath nozzle Nos. 1–5, and images are printed in the upper-edge portion by nozzle

Nos. 1–5 (fourth sub-group of dot-forming elements). Specifically, adopting an arrangement in which dots are formed in the upper-edge portion of a print medium with the aid of the fourth nozzle group Nr (fourth sub-group of dot-forming elements) above the opening of the downstream slot has the effect of allowing images to be printed without blank spaces in the upper-edge portion while preventing platen soiling.

[0104]

In the first embodiment, an upstream slot 26f is disposed underneath nozzle Nos. 7 and 8, and images are printed in the lower-edge portion by nozzle Nos. 7 and 8 in accordance with a first image-printing mode. The second embodiment is similar in the sense that images are printed in the lower-edge portion by nozzle Nos. 9–11, which are disposed above the slot. The relation between the upstream slot and the nozzles for printing images in the lower-edge portion of printing paper is not limited, however, by the embodiments adopted for the first and second embodiments. The embodiment in which each nozzle row has 48 nozzles may, for example, be configured such that an upstream slot is disposed underneath nozzle Nos. 31–34, and images are printed in the lower-edge portion by nozzle Nos. 31–34 (second sub-group of dot-forming elements). Specifically, adopting an arrangement in which dots are formed in the lower-edge portion of a print medium with the aid of the second sub-group of dot-forming elements above the opening of the upstream slot has the effect of allowing images to be printed without blank spaces in the lower-edge portion while preventing platen soiling. The first to fourth nozzle groups should each contain one or more nozzles.

[0105]

D2. Modification 2

The image-printing mode of the first embodiment involved performing constant feeding in 1-dot increment, and the image-printing mode of the second embodiment involved performing constant feeding in 3-dot increment, in

accordance with upper- and lower-edge routines. However, the feeding method of the upper- and lower-edge routines is not limited thereby and may include constant feeding in 2- or 4-dot increments, depending on the nozzle pitch or the number of nozzles in a nozzle row. Alternatively, it is possible to adopt non-constant feeding. In other words, any other feeding method may be adopted as long as the maximum feed increment in the sub-scanning direction is less than the maximum feed increment in the sub-scanning direction for the intermediate routine. In should be noted that adopting smaller feed increments in the sub-scanning direction for the upper-edge routine allows the upper edge of printing paper to be recorded with the nozzles disposed further downstream in the sub-scanning direction. The downstream slot can therefore be narrowed, and the upper platen surface for supporting the printing paper can be broadened. Similarly, adopting smaller feed increments in the sub-scanning direction for the lower-edge routine allows the upper edge of printing paper to be recorded with the nozzles disposed further upstream in the sub-scanning direction. The upstream slot can therefore be narrowed, and the upper platen surface for supporting the printing paper can be broadened.

[0106]

Neither is the feeding method of the intermediate routine of the first image-printing mode limited to constant feeding in 11-dot increments or an non-constant feeding arrangement in which the system is repeatedly fed in 5-, 2-, 3-, and 6-dot increments in the order indicated. For example, feeding the system in 5-, 3-, 2-, and 6-dot increments may be adopted for the structure described in the first embodiment. Depending on the number of nozzles, the nozzle pitch, or the like, combinations of other feed increments may be adopted, or constant feeding methods involving other feed increments carried out. In other words, any type of secondary scan feeding may be adopted as long as the maximum feed increment in the sub-scanning direction is less than the

maximum feed increment in the sub-scanning direction for the upper or lower-edge routine.

[0107]

D3. Modification 3

The above-described embodiments were configured such that the images provided beyond the edges of printing paper extended over two raster lines along both the upper and lower edges in the first embodiment, and constituted 16 raster lines along the upper edge and 30 raster lines along the lower edge in the second embodiment. The images that extend beyond the edges of printing paper are not limited by these dimensions, however. For example, the width of the portion occupied by the image data D for an area lying outside the printing paper P beyond the upper edge Pf of the printing paper P may be half that of the downstream slot 26r. Similarly, the width of the portion occupied by the image data D for an area lying outside the printing paper P beyond the lower edge Pr of the printing paper P may be half that of the upstream slot 26f. In other words, the width of the portion occupied by the image data for an area lying outside a printing paper beyond either edge should be less than the width of the downstream slot 26r along the upper edge, and less than the width of the upstream slot 26f along the lower edge. Adopting this arrangement makes it possible to prevent the ink droplets Ip for recording the images lying beyond a printing paper P from being deposited on the upper surface of the platen 26 when the ends of the printing paper P fail to reach the intended position. Approximately the same amount of shift can be permitted both in cases in which the printing paper P is shifted upstream and in cases in which the paper is shifted downstream, assuming that the affected area is about half the slot width.

[0108]

D4. Modification 4

The present invention can be adapted to monochromatic printing in addition to color printing. The use of the present invention is not limited to

ink-jet printers alone and commonly includes all dot-recording devices in which images are recorded on the surface of a print medium by a print head having a plurality of dot-forming element arrays. As used herein, the term "dot-forming element" refers to a dot-forming constituent element such as an ink nozzle of an ink-jet printer.

[0109]

F5. Modification 5

In the above embodiments, software can be used to perform some of the functions carried out by hardware, or, conversely, hardware can be used to perform some of the functions carried out by software. For example, a host computer 90 can be used to perform some of the functions carried out by the CPU 41 (Fig. 3).

[0110]

The computer programs for performing such functions may be supplied as programs stored on floppy disks, CD-ROMs, and other types of computer-readable recording media. The host computer 90 may read the computer programs from these recording media and transfer the data to internal or external storage devices. Alternatively, the computer programs can be installed on the host computer 90 from a program-supplying device via a communications line. Computer programs stored by an internal storage device are executed by the host computer 90 when the functions of the computer programs are to be performed. Alternatively, computer programs stored on a storage medium may be executed directly by the host computer 90.

[0111]

As used herein, the term "host computer 90" refers both to a hardware device and to an operating system, and designates a hardware device capable of operating under the control of an operating system. Computer programs allow such a host computer 90 to perform the functions of the above-described

units. Some of the aforementioned functions can be performed by an operating system rather than an application program.

[0112]

As used herein, the term "computer-readable recording medium" is not limited to a portable recording medium such as a floppy disk or a CD-ROM and includes various RAMs, ROMs, and other internal computer storage devices as well as hard disks and other external storage devices fixed to the computer.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

a side view depicting the structure of the periphery of a print head for an ink-jet printer configured according to an embodiment of the present invention;

[Fig. 2]

a block diagram depicting the structure of the software for the present printing device;

[Fig. 3]

a diagram depicting overall structure of the printing device 22;

[Fig. 4]

a diagram depicting the arrangement of the ink-jet nozzles N in the print head 28;

[Fig. 5]

a plan view depicting the periphery of a platen 26;

[Fig. 6]

a flowchart depicting the sequence of printing routines;

[Fig. 7]

a plan view depicting the relation between image data D and printing paper P;

[Fig. 8]

a plan view depicting the relation between the image data D2 and printing paper P in the second image-printing mode;

[Fig. 9]

a diagram depicting the manner in which the front edge Pf of a sheet of printing paper P is transported over the platen 26;

[Fig. 10]

a diagram showing a case in which the front-edge portion Pf of a sheet of printing paper P reaches a point above the platen 26 of a printer pertaining to a comparative example;

[Fig. 11]

a diagram depicting the manner in which raster lines are recorded by particular nozzles in an area near the front edge (tip) of printing paper;

[Fig. 12]

a side view depicting the relation between the print head 28 and the printing paper P at the start of printing;

[Fig. 13]

a diagram depicting the manner in which raster lines are recorded by particular nozzles during a lower-edge routine;

[Fig. 14]

a plan view depicting the relation between the printing paper P and an upstream slot 26f during printing in the lower-edge portion Pr of the printing paper P;

[Fig. 15]

a side view depicting the relation between the printing paper P and the print head 28 during printing along the lowermost edge of the printing paper;

[Fig. 16]

a diagram depicting the manner in which raster lines are recorded by particular nozzles in accordance with the second image-printing mode;

[Fig. 17]

a side view depicting the relation of a print head 28a with an upstream slot 26fa and a downstream slot 26ra according to a second embodiment;

[Fig. 18]

a diagram depicting the manner in which raster lines are recorded by particular nozzles during the upper-edge routine of the second embodiment;

[Fig. 19]

a diagram depicting the manner in which raster lines are recorded by particular nozzles during the upper-edge routine of the second embodiment;

[Fig. 20]

a diagram depicting the manner in which raster lines are recorded by particular nozzles during the lower-edge routine of the second embodiment;

[Fig. 21]

a diagram depicting the manner in which raster lines are recorded by particular nozzles during the lower-edge routine of the second embodiment;

[Fig. 22]

a diagram depicting the manner in which raster lines are recorded by particular nozzles in accordance with the second image-printing mode of the second embodiment; and

[Fig. 23]

a side view depicting the periphery of a print head for a conventional printer.

[Description of the Symbols]

12 ... scanner

14 ... keyboard

15 ... floppy drive

16 ... hard disk

18 ... modem

21 ... CRT

22, 22n ...printer

23 ... paper feed motor

24 ... carriage motor

25a, 25b ... upstream paper feed roller

25c, 25d ... downstream paper feed roller

25p, 25q ... upstream paper feed roller

25r, 25s ... downstream paper feed roller

26, 26a, 26b, 26n, 26o ... platen

26c ... central portion

26f, 26fa, 26fb ... upstream slot

26na ... left slot

26nb ... right slot

26r, 26ra, 26rb ...downstream slot

27, 27f, 27r ... absorbent member

28, 28a, 28b, 28o ... print head

29a, 29b ... guide

31 ... carriage

32 ... control panel

34 ... sliding shaft

36 ... drive belt

38 ... pulley

39 ... position sensor

40 ... control circuit

41 ... CPU

42 ... PROM

43 ... RAM

44 ... drive buffer

45 ... PC interface

60 ... print head unit

61-66 ... ink-injecting head

61b-66b ... ink-injecting head

67 ... introduction tube

68 ... ink conduit

71 ... cartridge

72 ... color-ink cartridge

80 ... bus

81 ... CPU

82 ... ROM

83 ... RAM

84 ... input interface

85 ... output interface

86 ... CRTC

88 ... SIO

90 ... host computer

91 ... video driver

95 ... application program

96 ... printer driver

97 ... resolution conversion module

98 ... color correction module

99 ... halftone module

100 ... rasterizer

D, Dn ... image data

DT ... dot-forming pattern table

FD ... floppy disk

Ip ... ink particle

L31 ... distance for printing and secondary-scan feeding by upstream paper feed rollers alone

L41 ... distance for printing and secondary-scan feeding by downstream paper feed rollers alone

L32 ... distance for printing and secondary-scan feeding by upstream paper feed rollers alone

L42 ... distance for printing and secondary-scan feeding by downstream paper feed rollers alone

LUT ... color correction table

N1 ... group of nozzles used for upper-edge routine

N2 ... group of nozzles used for transitional routine

N3 ... group of nozzles used for intermediate routine

N4 ... group of nozzles used for intermediate routine

N5 ... group of nozzles used for lower-edge routine

Nf ... upstream group of nozzles

Nr ... downstream group of nozzles

Nz ... ink-jet nozzle

ORG ... primary-color image data

P ... printing paper

PD ... print data

PE ... piezoelement

PNT ... public telephone network

Pa ... left edge (portion)

Pb ... right edge (portion)

Pf ... upper edge (portion)

Pr ... lower edge (portion)

R26 ... range containing central portion of platen

Rf ... range containing upstream slot

Rr ... range containing downstream slot

SV ... server

k ... nozzle pitch

[DOCUMENT NAME] ABSTRACT

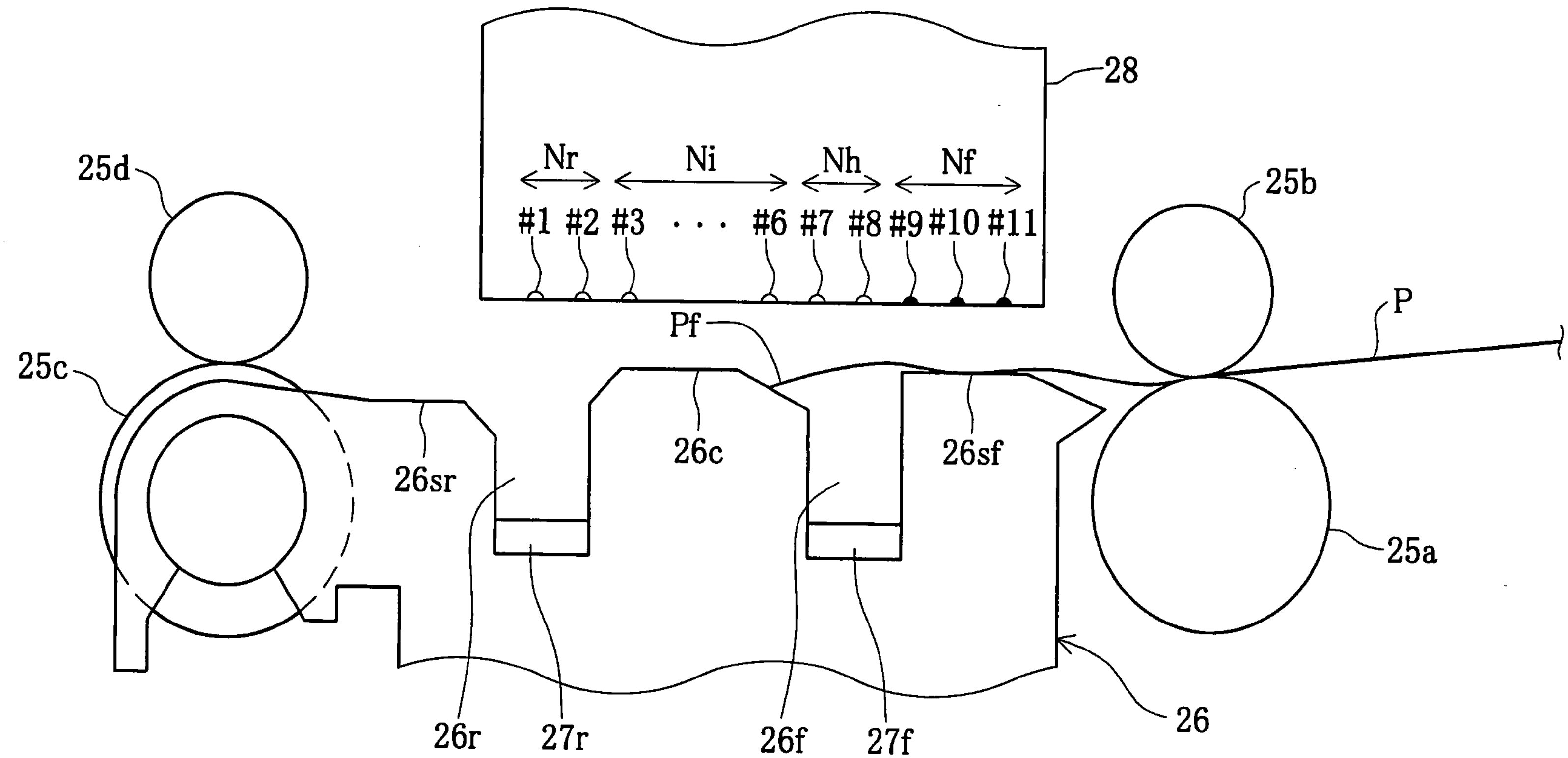
[ABSTRACT]

[OBJECTIVE] To allow images to be printed up to the edges of printing paper while preventing ink droplets from depositing on the platen

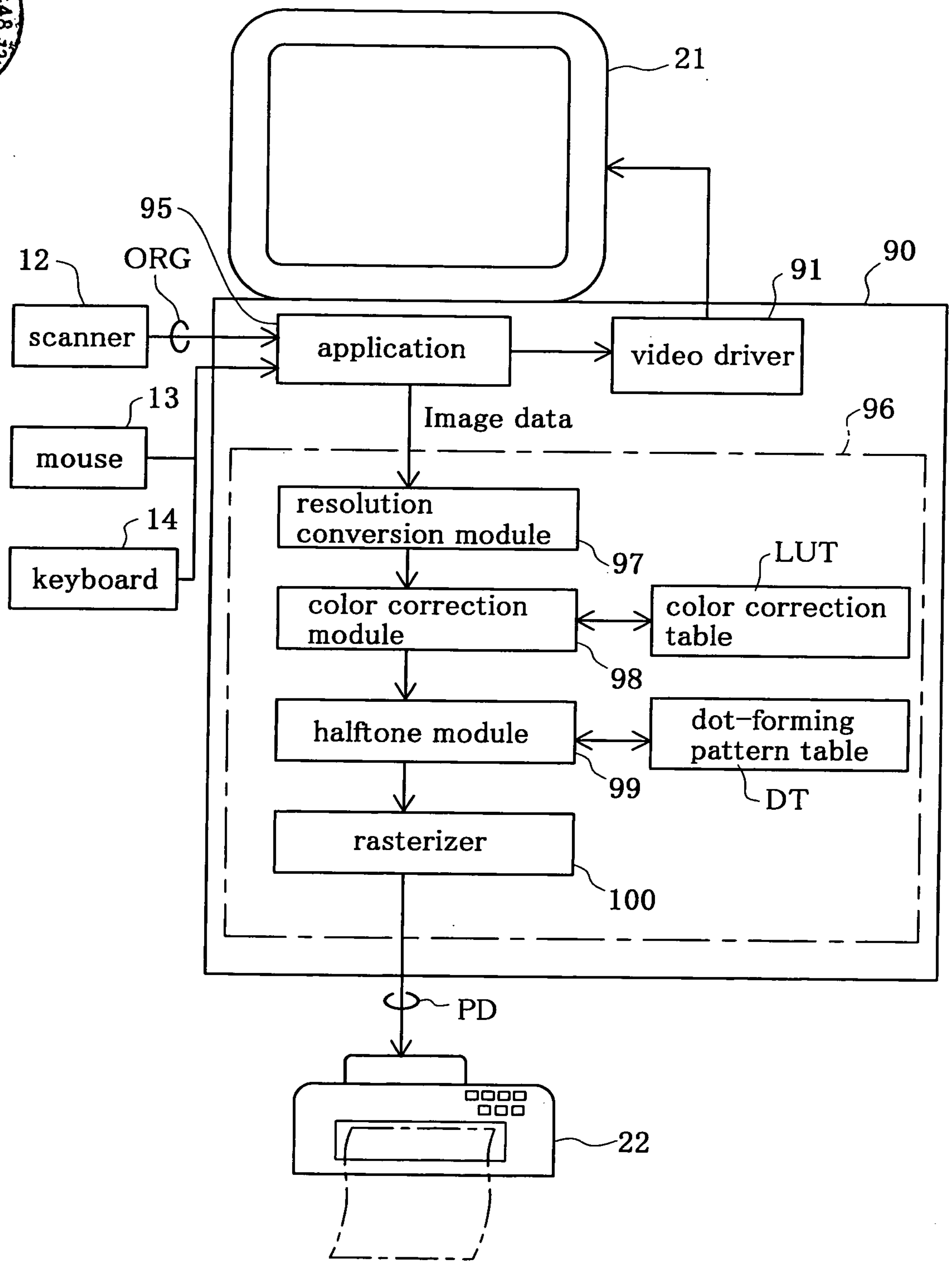
[MEANS FOR PROBLEM SOLVING] A platen 26 of the printer according to the invention comprises, in order from the upstream side in the sub-scanning direction, an upstream support 26sf, an upstream slot 26f, a central support 26c, and a downstream slot 26r. The printer has a first image-printing mode for printing images without blank spaces all the way to the lower and upper edges of printing paper, and a second image-printing mode for printing images in the regular manner, with blank spaces formed along the upper and lower edges of the printing paper during printing. The second image-printing mode is performed using all the nozzles (nozzle Nos. 1–11 from nozzle groups Nr, Ni, Nh, and Nf) of the print head 28 throughout the entire process of printing images on printing paper. By contrast, the first image-printing mode is performed using solely nozzle Nos. 1–8 (nozzle groups Nr, Ni, and Nh) of the print head 28.

[SELECTED FIGURE] Fig. 1

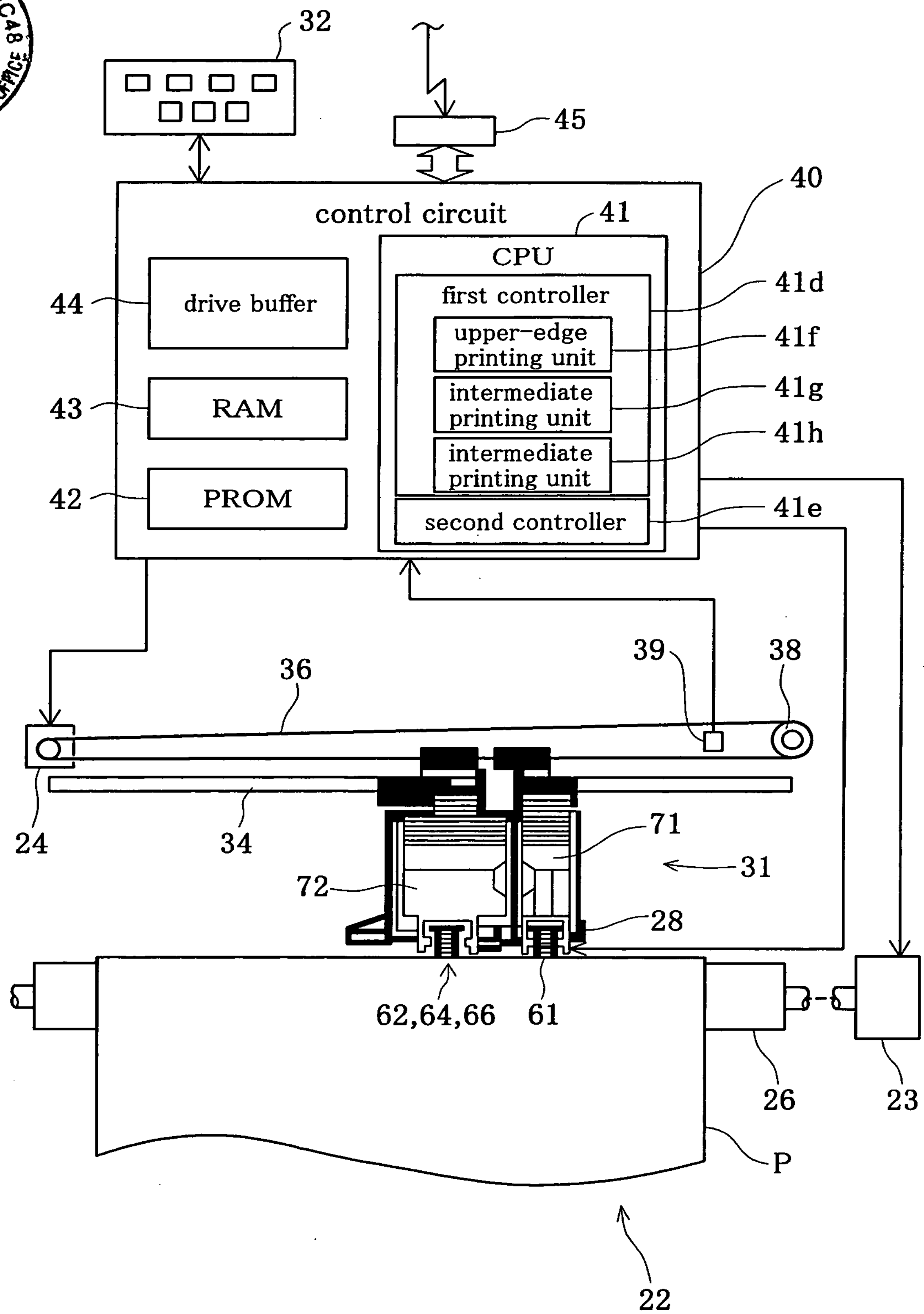
【DOCUMENT NAME】 DRAWINGS
【Fig.1】



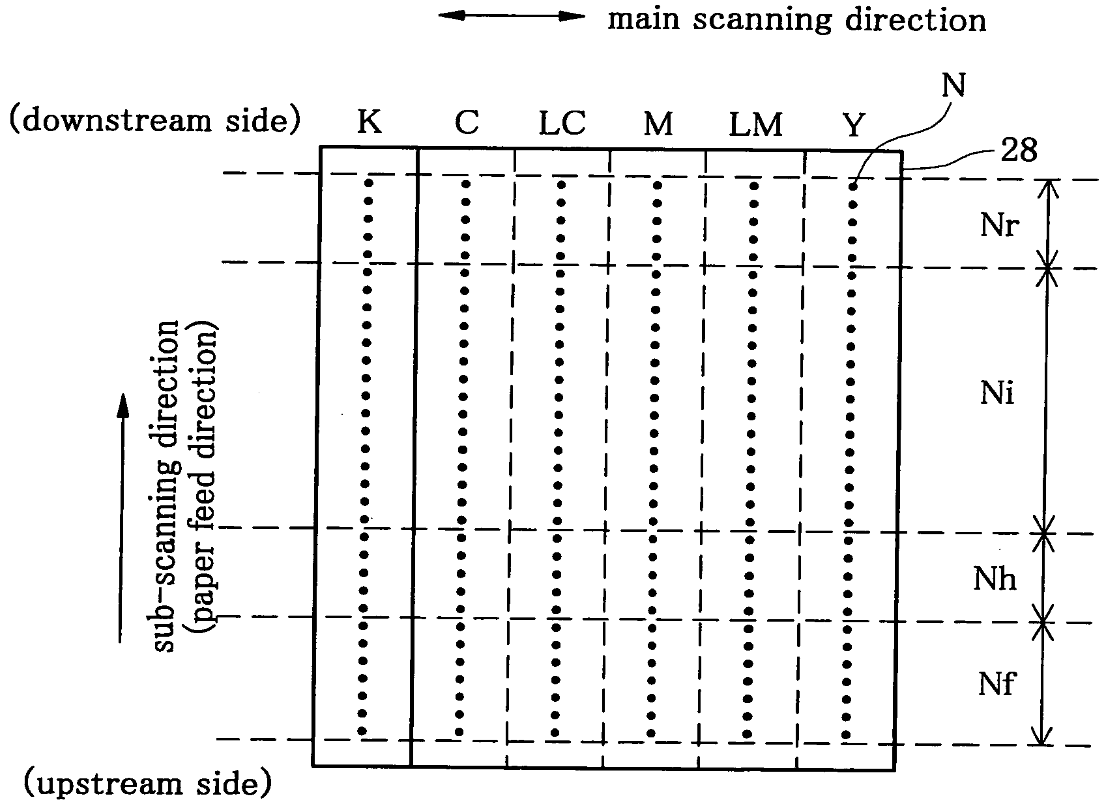
【Fig.2】


21
95
12
ORG
90
91
scanner
application
video driver
13
Image data
96
mouse
resolution conversion module
14
97
LUT
keyboard
color correction module
color correction table
98
halftone module
dot-forming pattern table
99
DT
rasterizer
100
PD
22

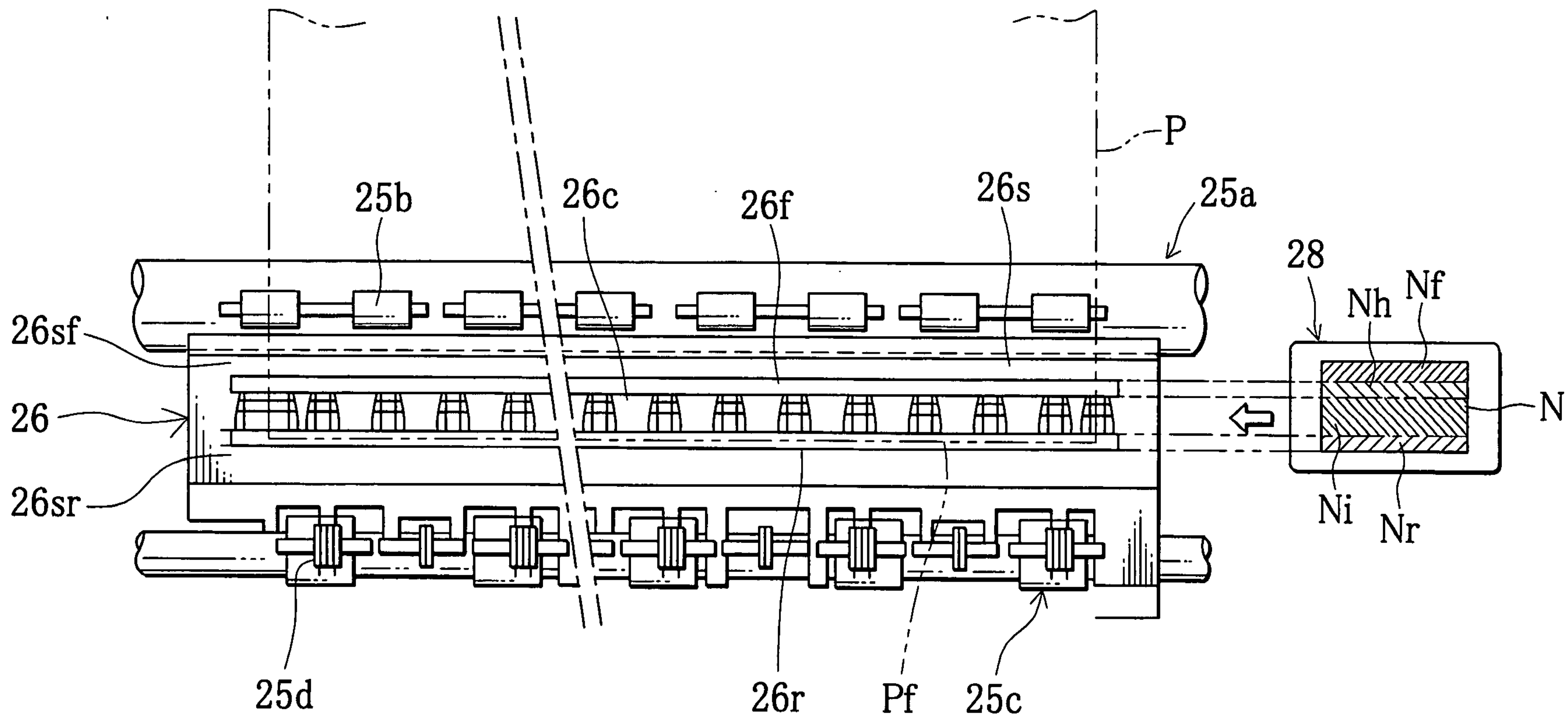
【Fig.3】


32
45
40
control circuit
41
CPU
44
drive buffer
first controller
41d
upper−edge printing unit
41f
43
RAM
intermediate printing unit
41g
intermediate printing unit
41h
42
PROM
second controller
41e
39
38
36
24
34
71
31
72
28
62,64,66
61
26
23
P
22

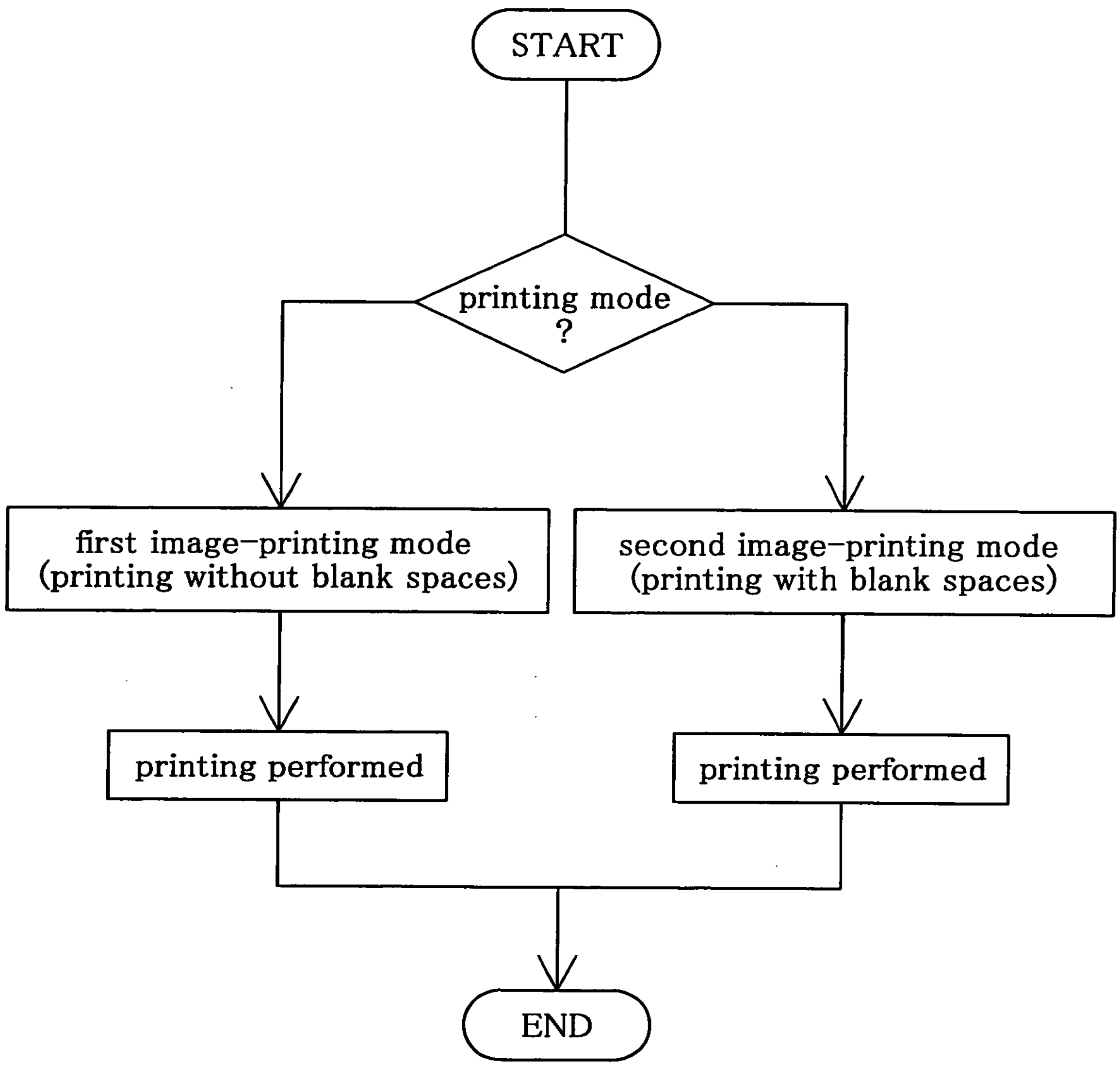
【Fig.4】


main scanning direction
(downstream side)
K
C
LC
M
LM
Y
N
28
Nr
Ni
Nh
Nf
sub-scanning direction
(paper feed direction)
(upstream side)

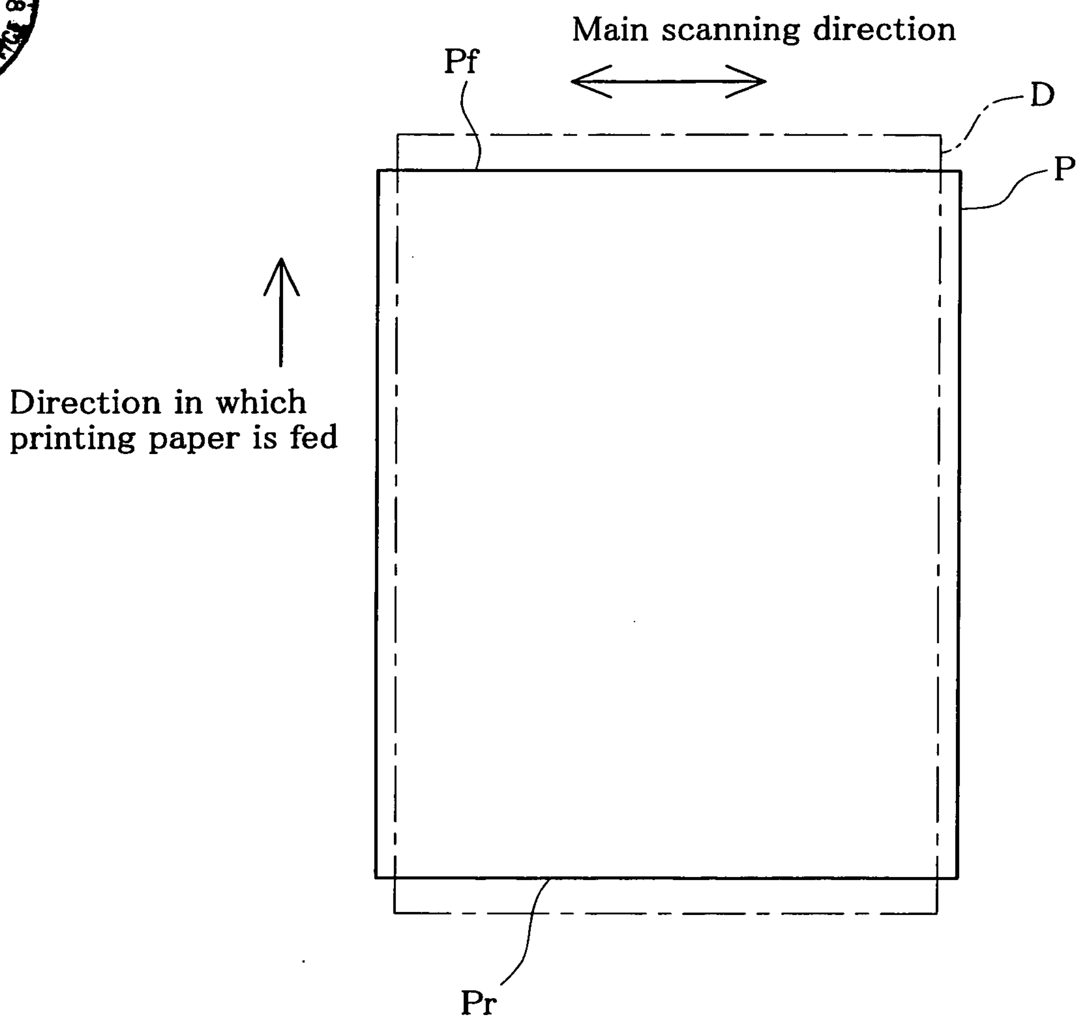
【Fig.5】



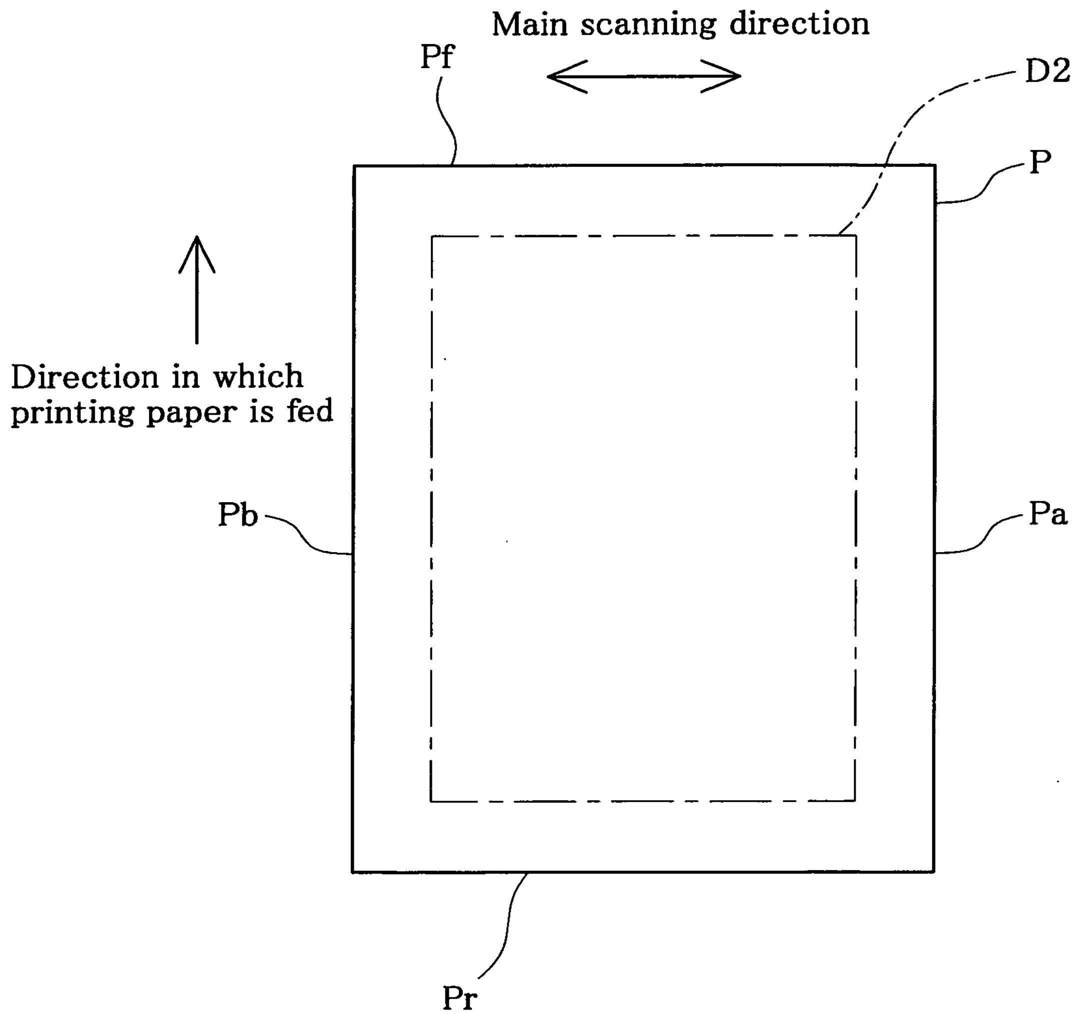
【Fig.6】


START
printing mode ?
first image-printing mode (printing without blank spaces)
second image-printing mode (printing with blank spaces)
printing performed
printing performed
END

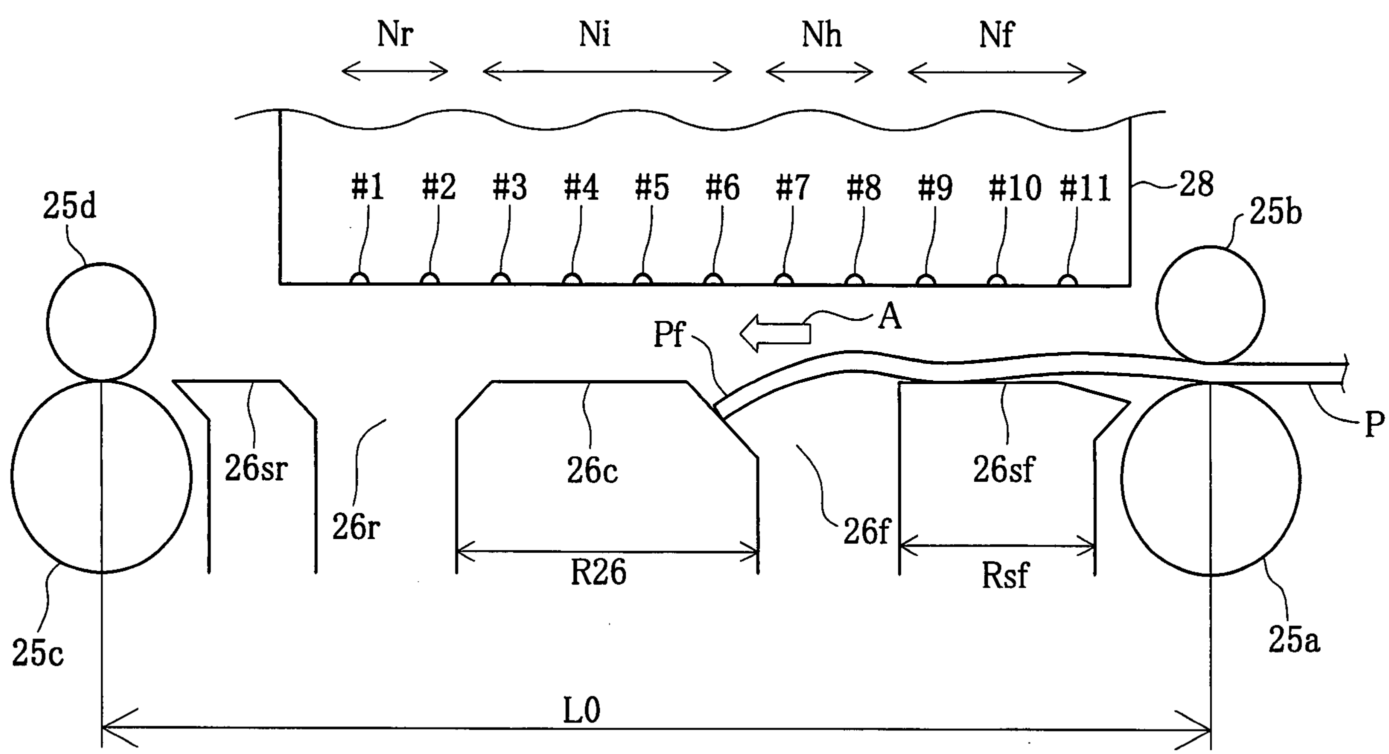
【Fig.7】


Main scanning direction
Pf
D
P
Direction in which
printing paper is fed
Pr

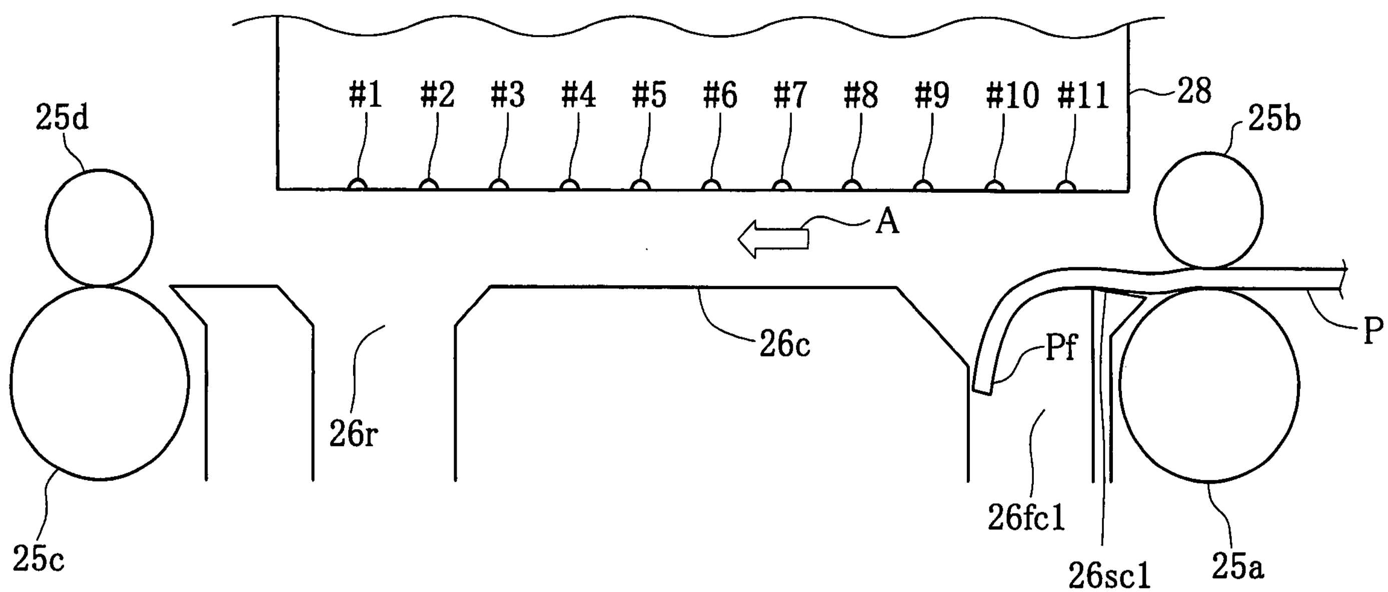
【Fig.8】


Main scanning direction
Pf
D2
P
Direction in which
printing paper is fed
Pb
Pa
Pr

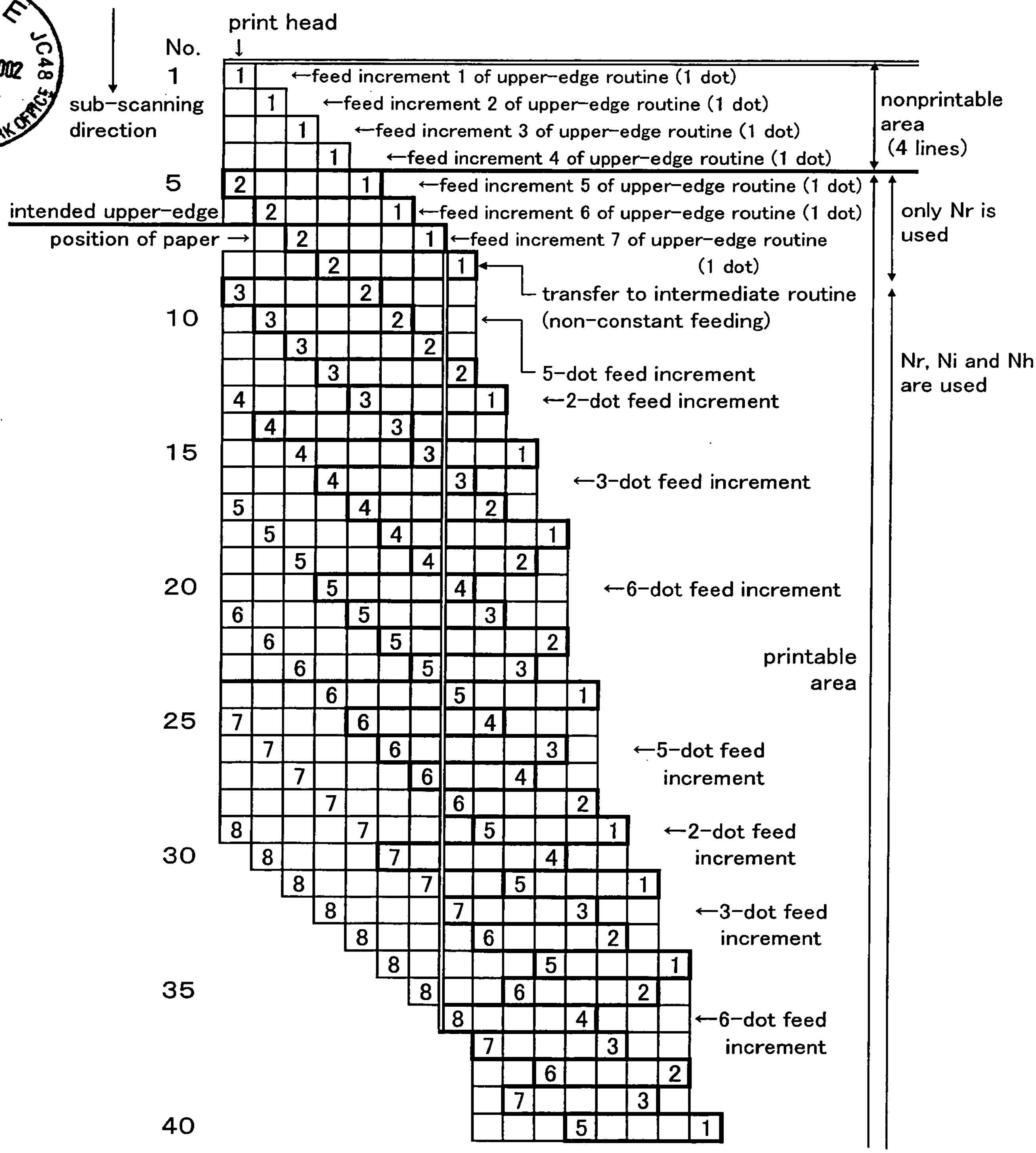
【Fig.9】


Nr
Ni
Nh
Nf
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
28
25d
25b
Pf
A
26sr
26r
26c
26f
26sf
P
R26
Rsf
25c
25a
L0

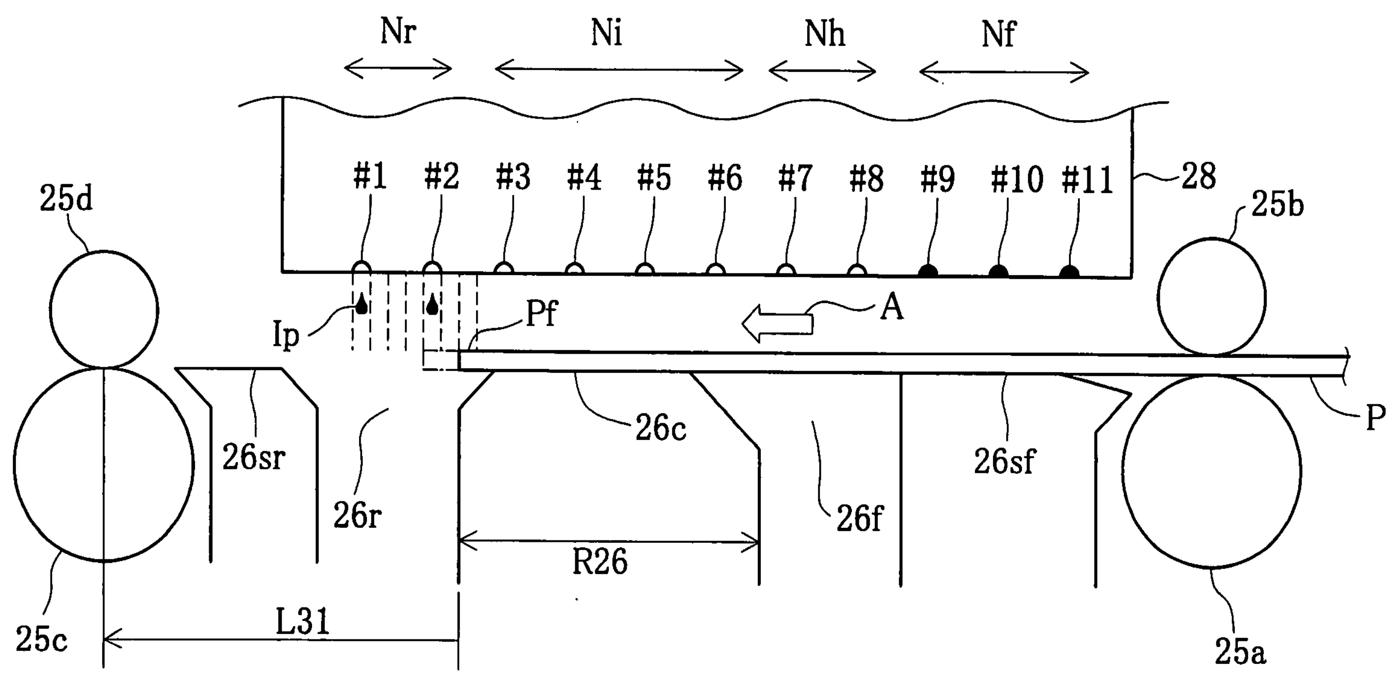
【Fig.10】



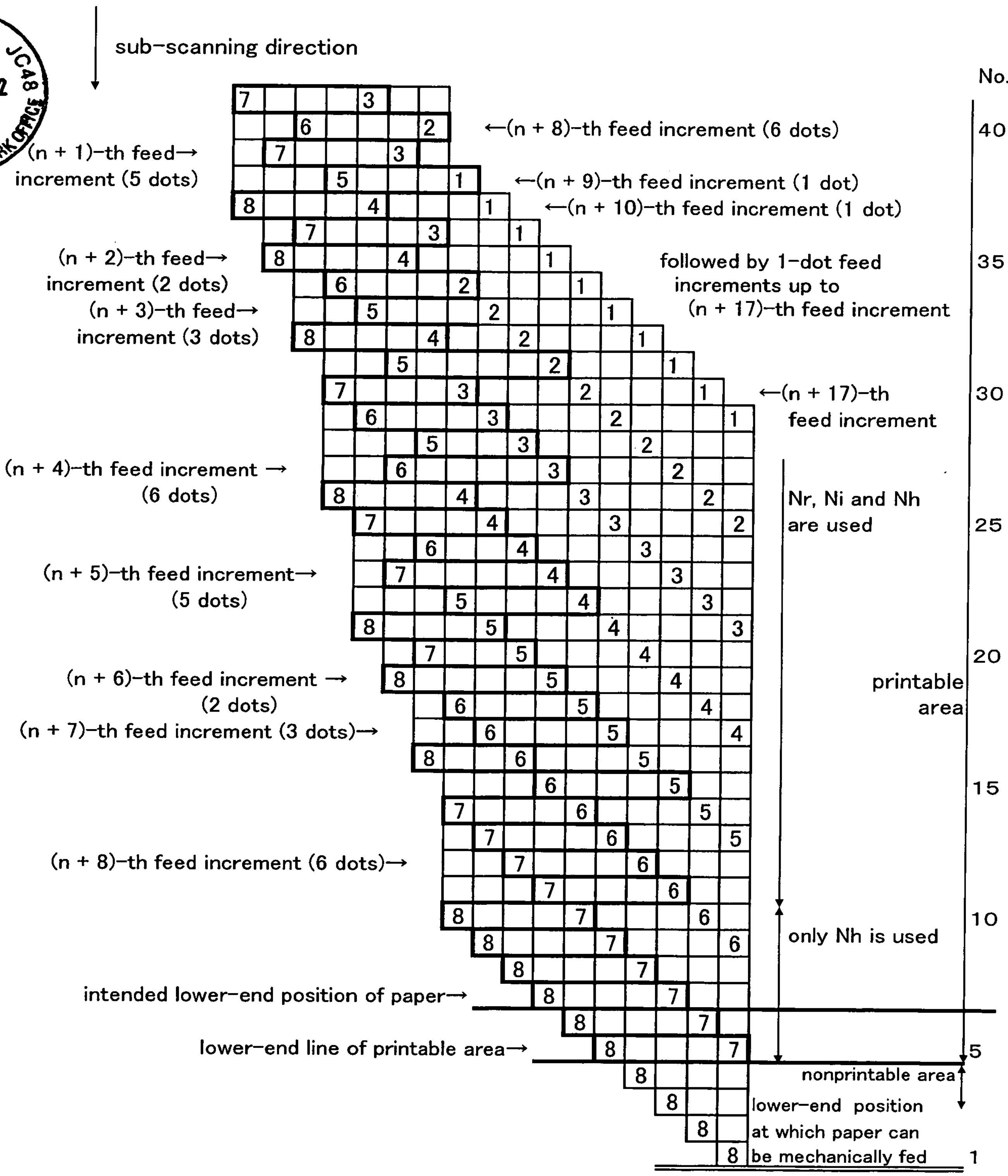
【Fig.11】


print head
No.
sub-scanning direction
←feed increment 1 of upper-edge routine (1 dot)
←feed increment 2 of upper-edge routine (1 dot)
←feed increment 3 of upper-edge routine (1 dot)
←feed increment 4 of upper-edge routine (1 dot)
←feed increment 5 of upper-edge routine (1 dot)
←feed increment 6 of upper-edge routine (1 dot)
←feed increment 7 of upper-edge routine (1 dot)
intended upper-edge position of paper →
transfer to intermediate routine (non-constant feeding)
5-dot feed increment
←2-dot feed increment
←3-dot feed increment
←6-dot feed increment
←5-dot feed increment
←2-dot feed increment
←3-dot feed increment
←6-dot feed increment
nonprintable area (4 lines)
only Nr is used
Nr, Ni and Nh are used
printable area

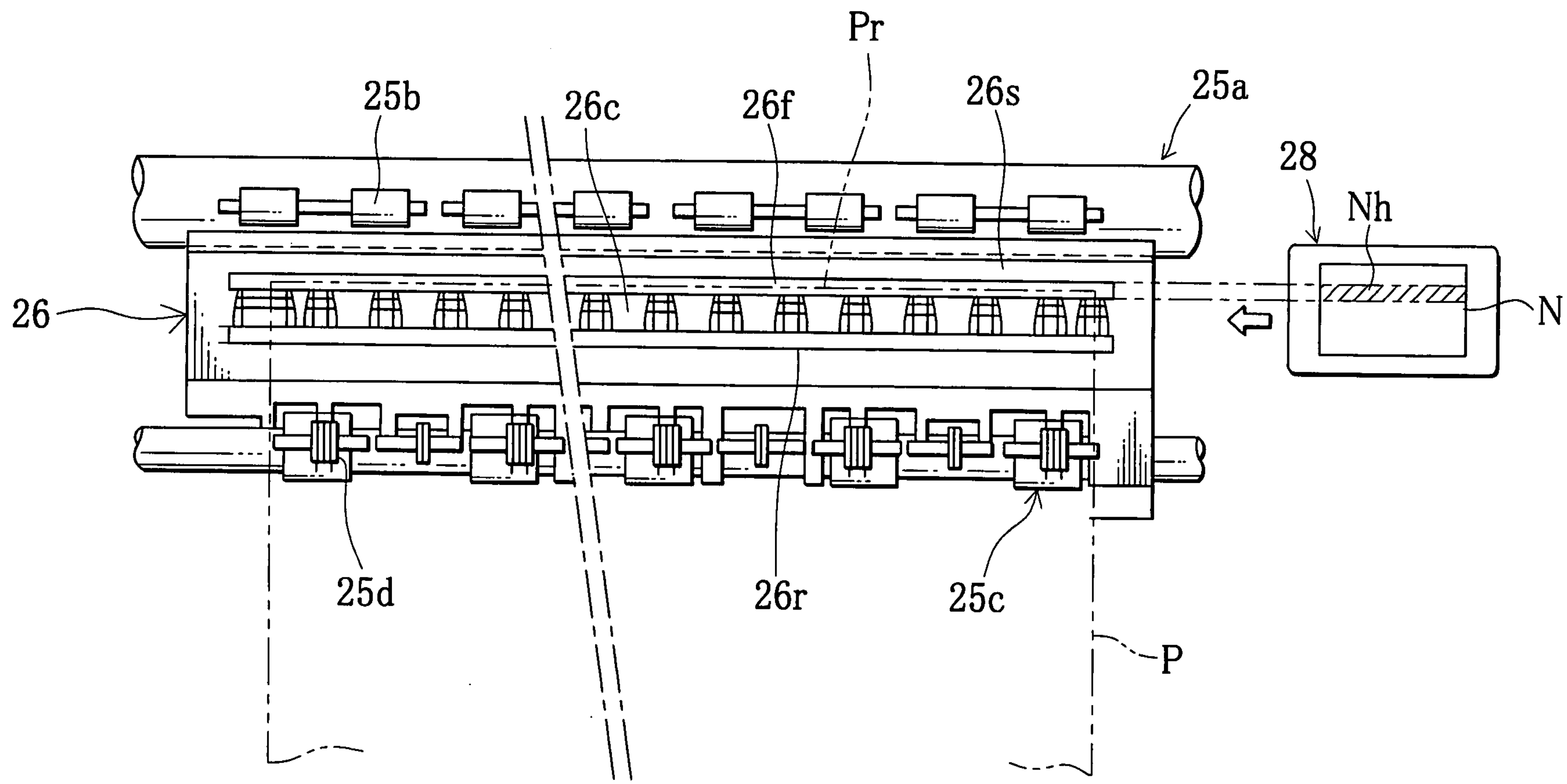
【Fig.12】


Nr
Ni
Nh
Nf
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
28
25d
25b
Ip
Pf
A
26sr
26r
26c
26f
26sf
P
R26
L31
25c
25a

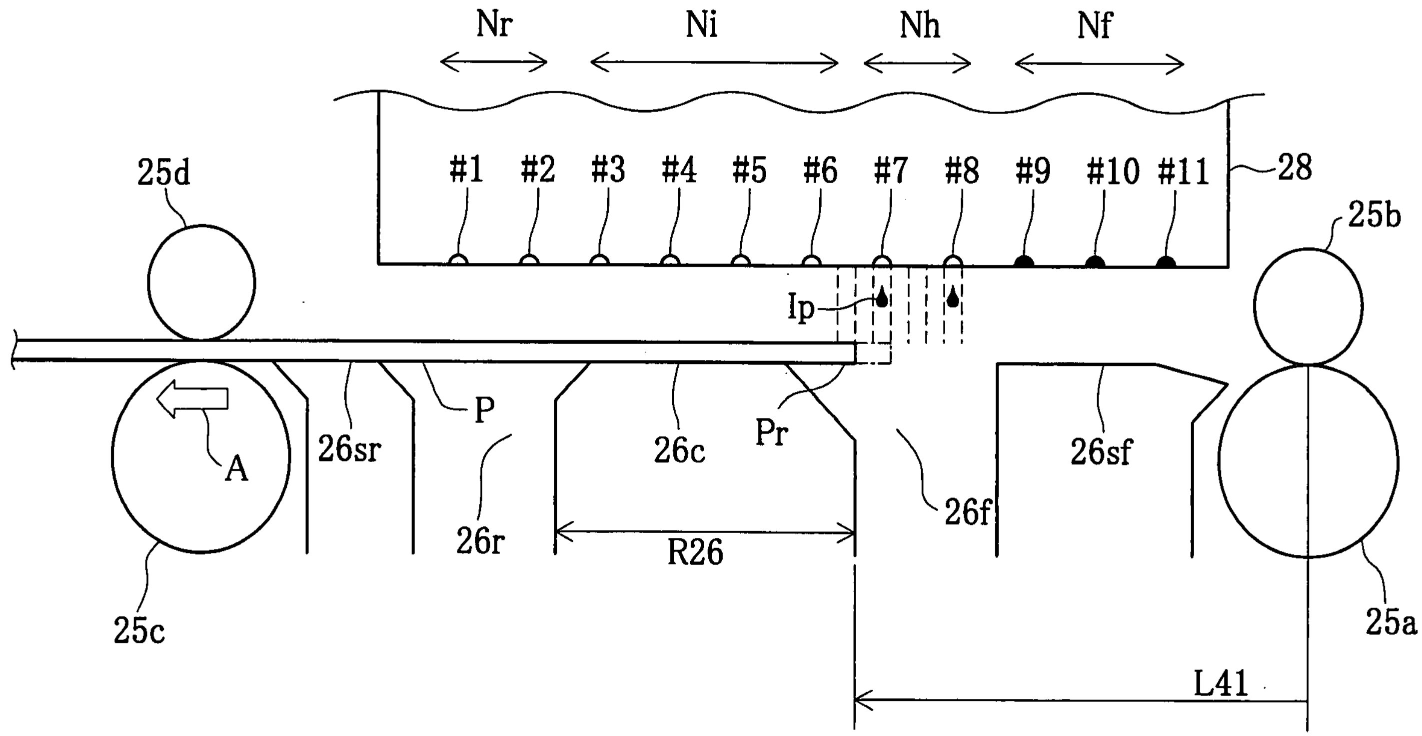
【Fig.13】


sub-scanning direction
No.
←(n + 8)-th feed increment (6 dots)
(n + 1)-th feed→ increment (5 dots)
←(n + 9)-th feed increment (1 dot)
←(n + 10)-th feed increment (1 dot)
(n + 2)-th feed→ increment (2 dots)
followed by 1-dot feed increments up to (n + 17)-th feed increment
(n + 3)-th feed→ increment (3 dots)
←(n + 17)-th feed increment
(n + 4)-th feed increment → (6 dots)
Nr, Ni and Nh are used
(n + 5)-th feed increment→ (5 dots)
(n + 6)-th feed increment → (2 dots)
printable area
(n + 7)-th feed increment (3 dots)→
(n + 8)-th feed increment (6 dots)→
only Nh is used
intended lower-end position of paper→
lower-end line of printable area→
nonprintable area
lower-end position at which paper can be mechanically fed
40
35
30
25
20
15
10
5
1

【Fig.14】

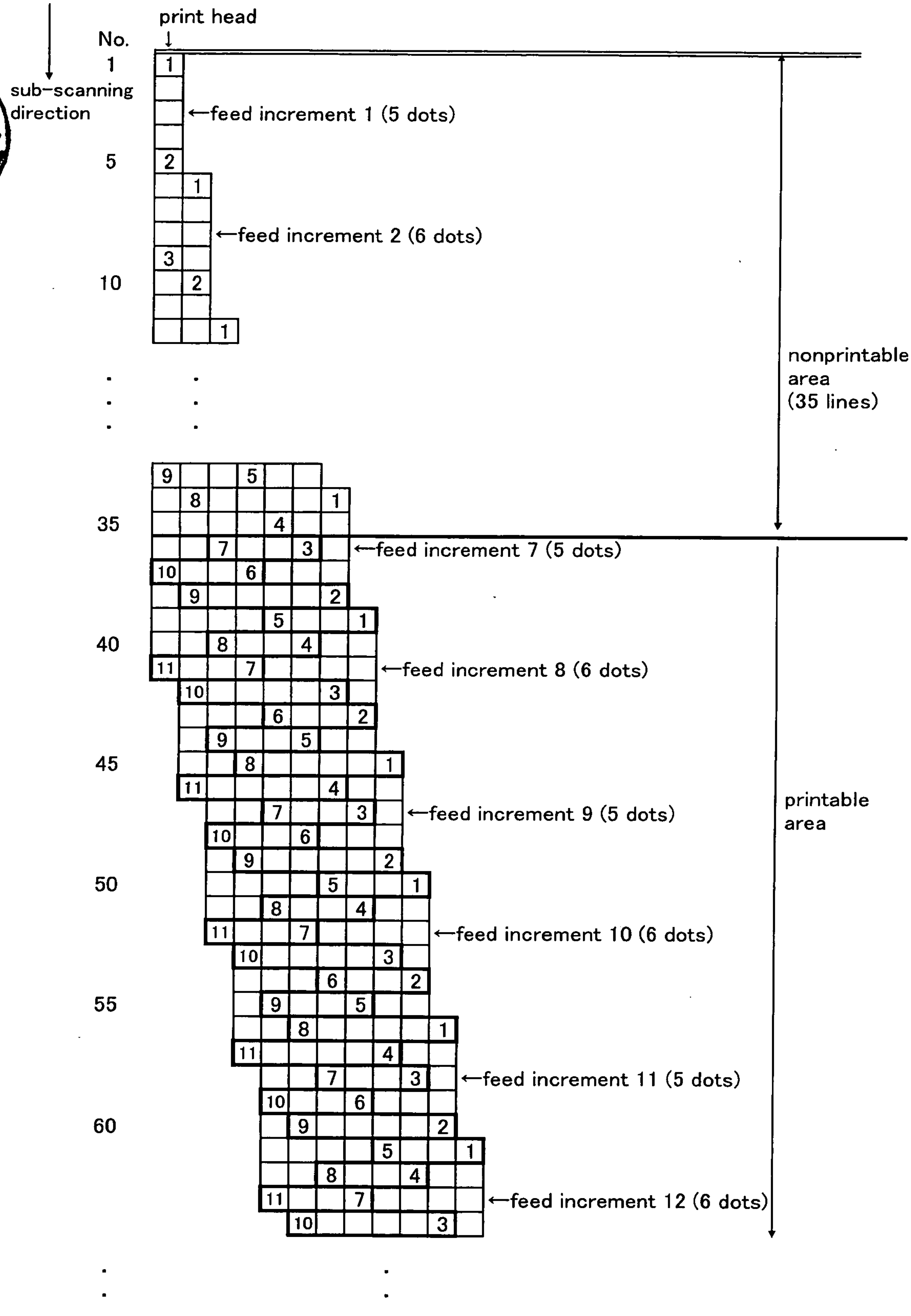


【Fig.15】



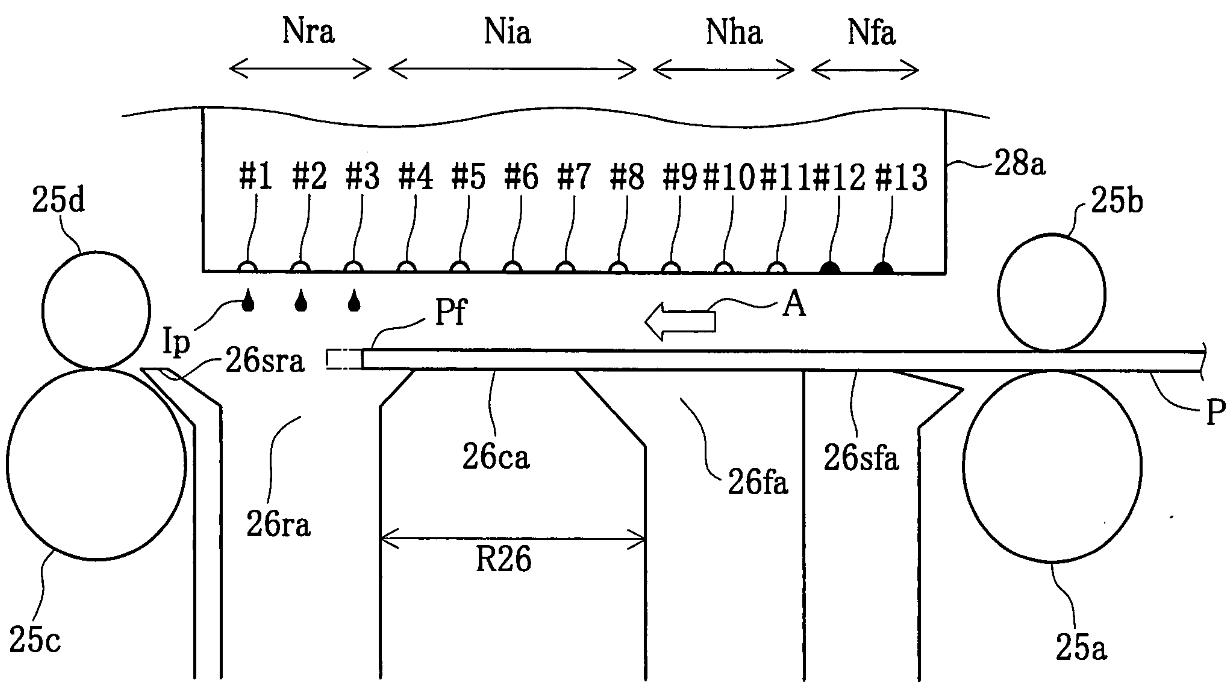
Nr
Ni
Nh
Nf
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
28
25d
25b
Ip
P
A
26sr
26r
26c
Pr
26f
26sf
R26
25c
25a
L41

【Fig.16】

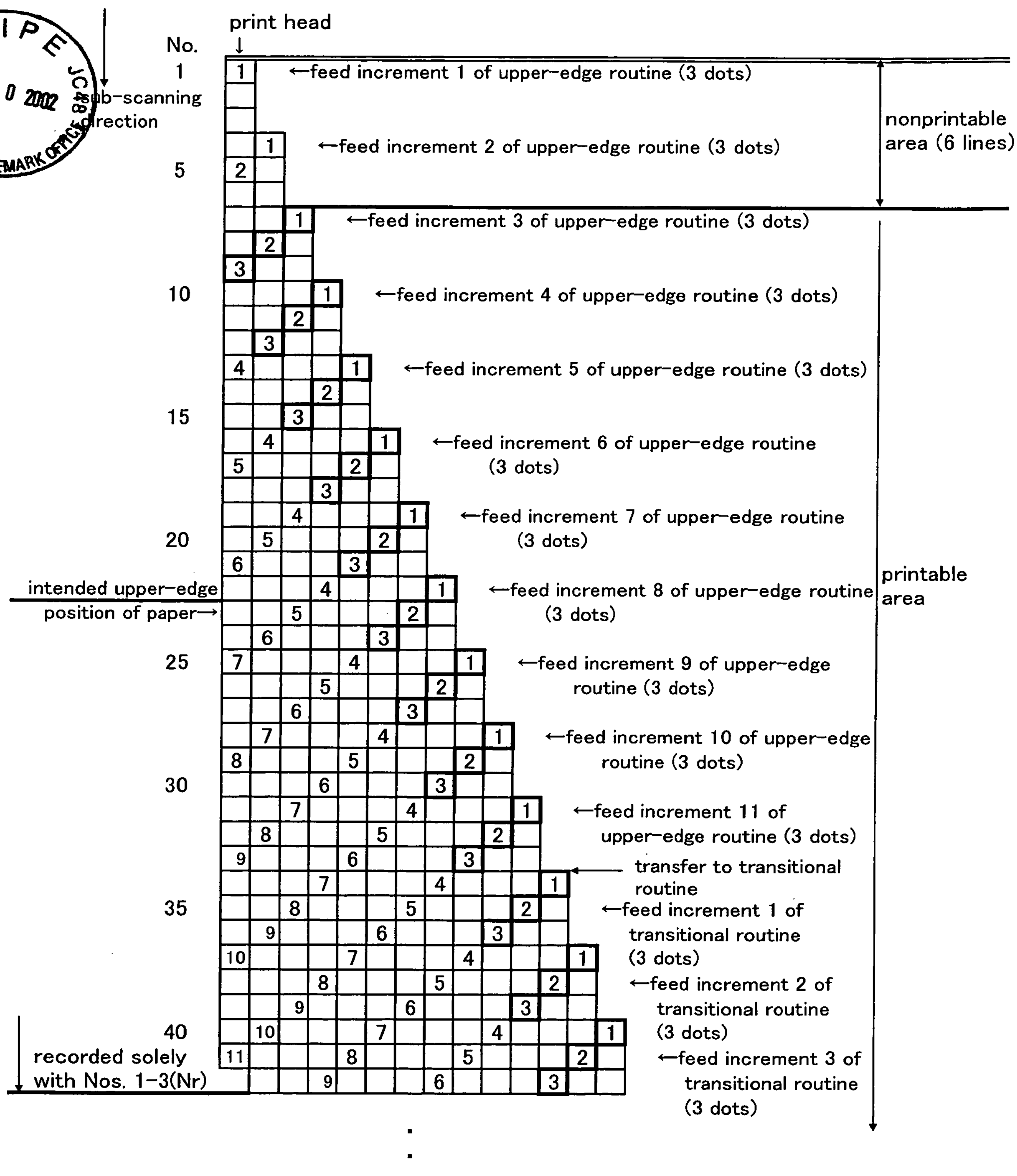


sub-scanning direction
No.
print head
feed increment 1 (5 dots)
feed increment 2 (6 dots)
feed increment 7 (5 dots)
feed increment 8 (6 dots)
feed increment 9 (5 dots)
feed increment 10 (6 dots)
feed increment 11 (5 dots)
feed increment 12 (6 dots)
nonprintable area (35 lines)
printable area

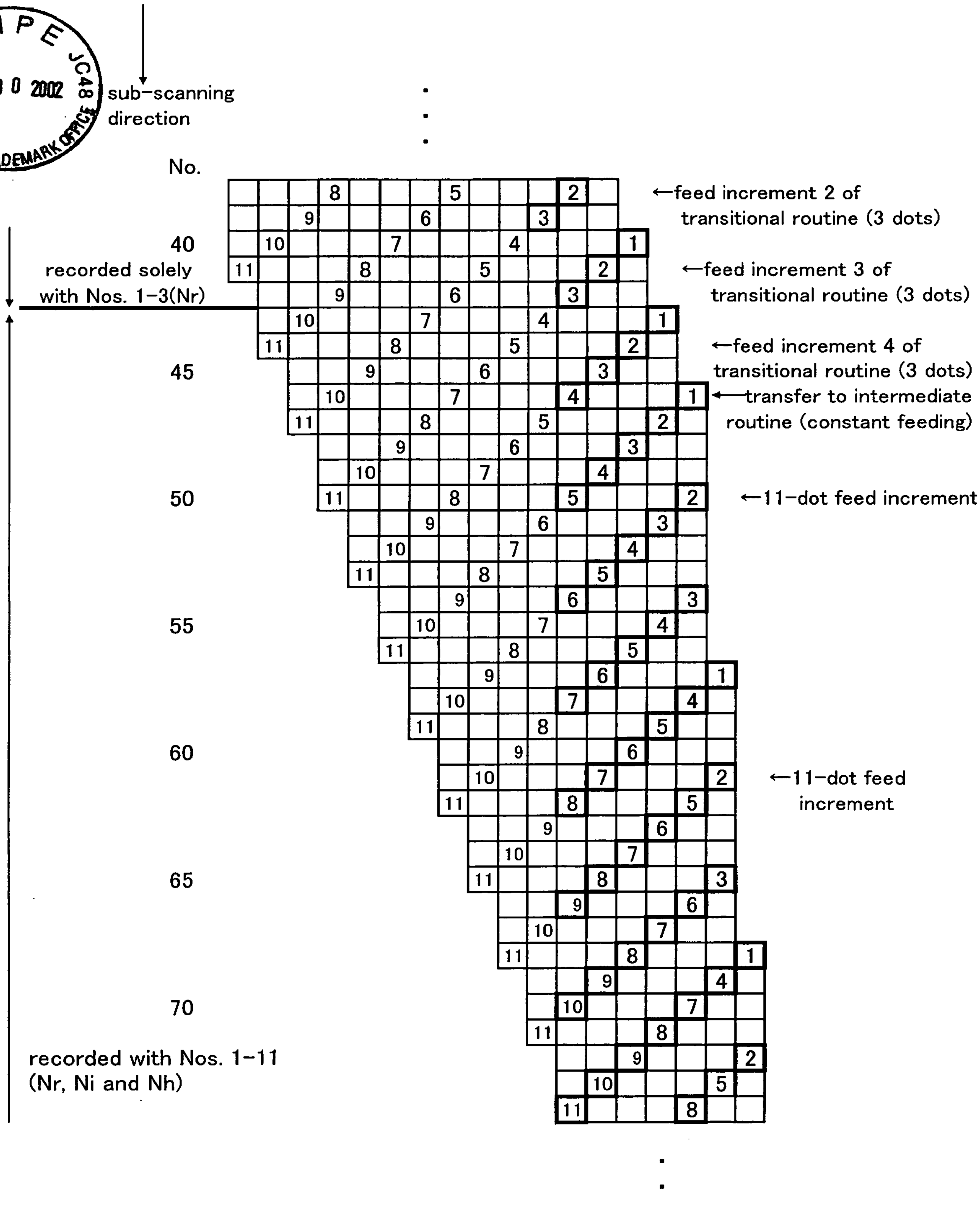
【Fig.17】


Nra
Nia
Nha
Nfa
#1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #11 #12 #13
28a
25d
25b
Ip
Pf
A
26sra
P
26ca
26fa
26sfa
26ra
R26
25c
25a

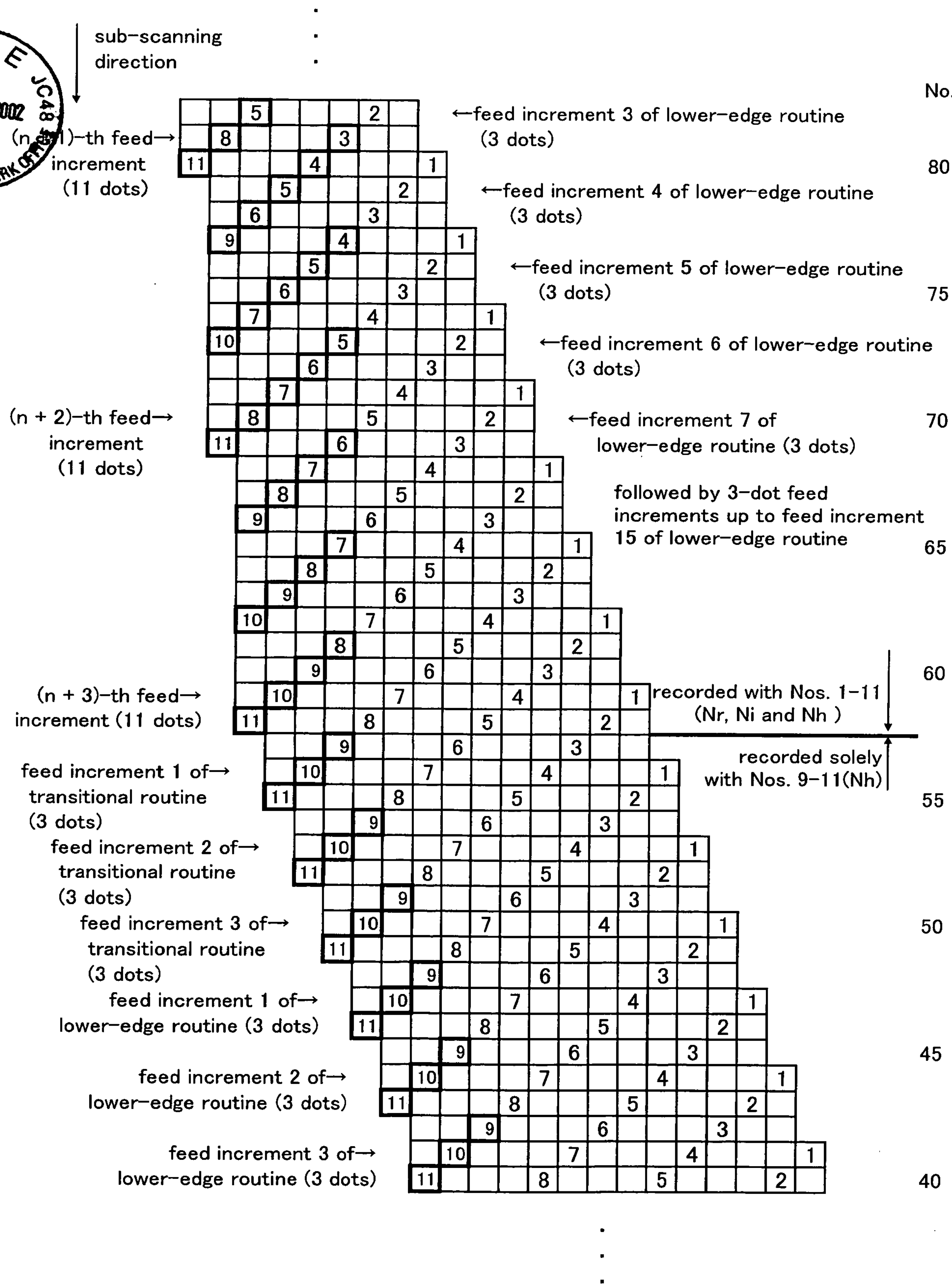
【Fig.18】


sub-scanning direction
No.
print head
1
5
10
15
20
25
30
35
40
←feed increment 1 of upper-edge routine (3 dots)
←feed increment 2 of upper-edge routine (3 dots)
nonprintable area (6 lines)
←feed increment 3 of upper-edge routine (3 dots)
←feed increment 4 of upper-edge routine (3 dots)
←feed increment 5 of upper-edge routine (3 dots)
←feed increment 6 of upper-edge routine (3 dots)
←feed increment 7 of upper-edge routine (3 dots)
intended upper-edge position of paper→
←feed increment 8 of upper-edge routine (3 dots)
printable area
←feed increment 9 of upper-edge routine (3 dots)
←feed increment 10 of upper-edge routine (3 dots)
←feed increment 11 of upper-edge routine (3 dots)
transfer to transitional routine
←feed increment 1 of transitional routine (3 dots)
←feed increment 2 of transitional routine (3 dots)
←feed increment 3 of transitional routine (3 dots)
recorded solely with Nos. 1-3(Nr)

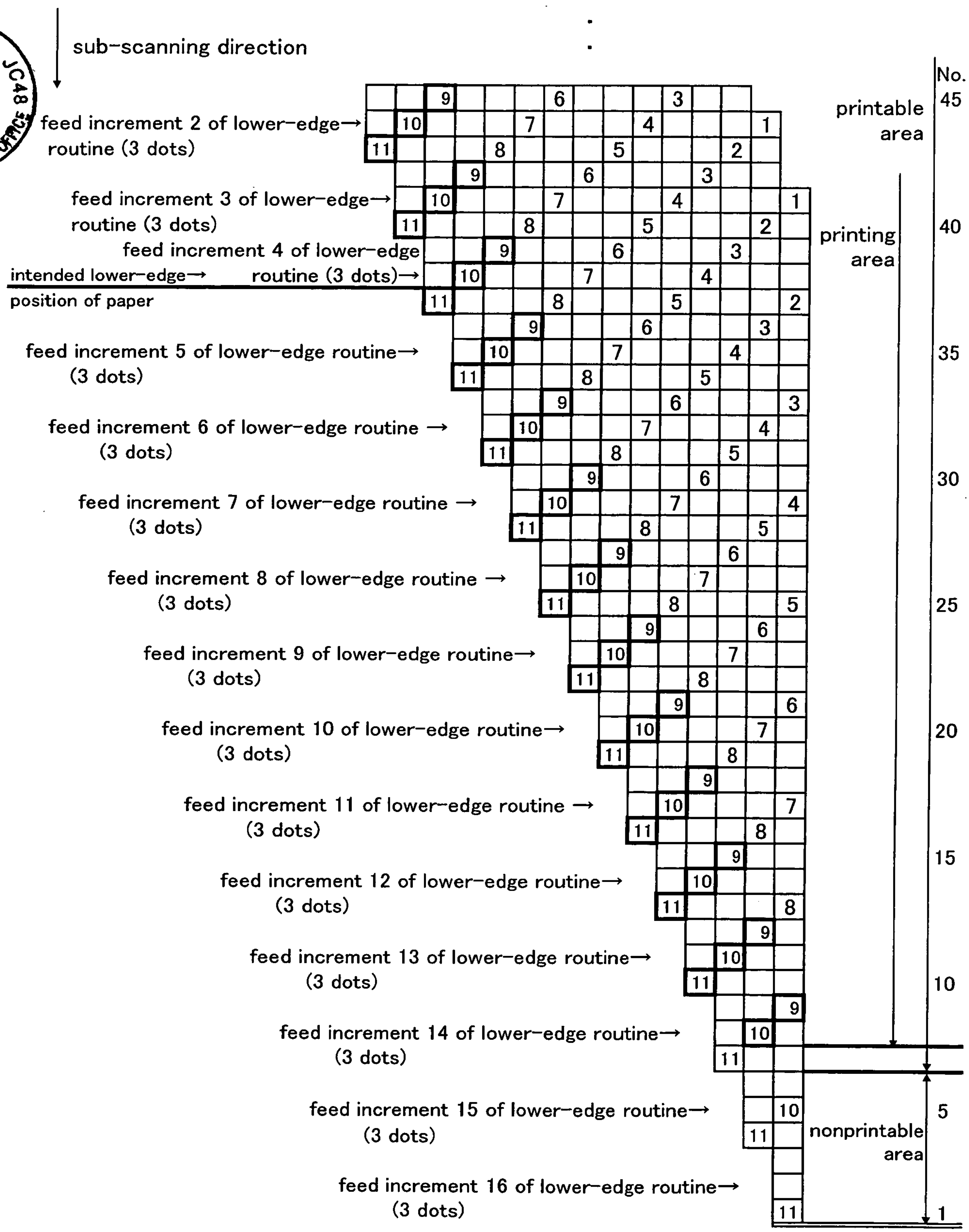
【Fig.19】


sub-scanning direction
No.
40
45
50
55
60
65
70
recorded solely with Nos. 1-3(Nr)
recorded with Nos. 1-11 (Nr, Ni and Nh)
←feed increment 2 of transitional routine (3 dots)
←feed increment 3 of transitional routine (3 dots)
←feed increment 4 of transitional routine (3 dots)
←transfer to intermediate routine (constant feeding)
←11-dot feed increment
←11-dot feed increment

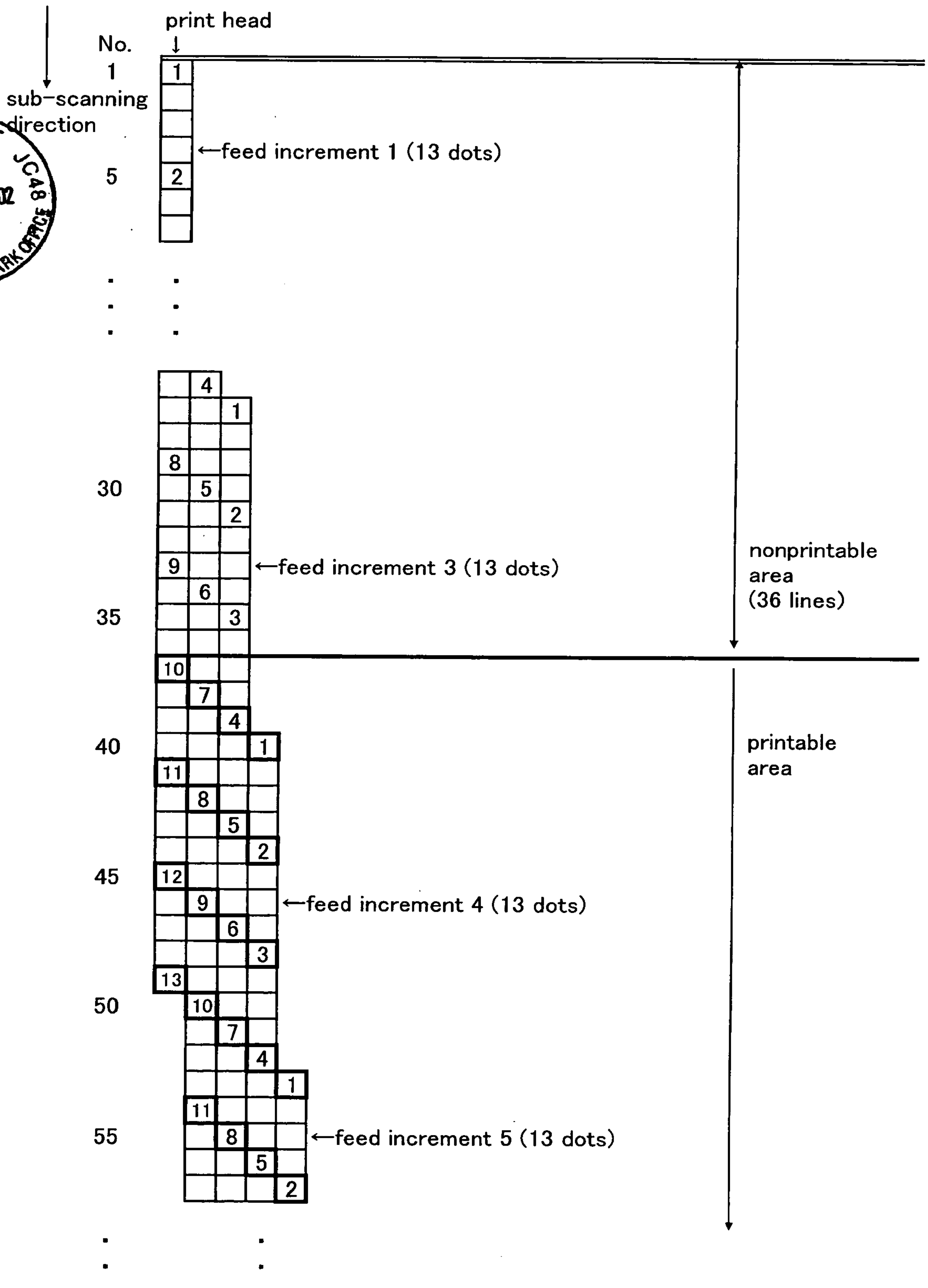
【Fig.20】


sub-scanning direction
No.
←feed increment 3 of lower-edge routine (3 dots)
(n + 1)-th feed→ increment (11 dots)
80
←feed increment 4 of lower-edge routine (3 dots)
←feed increment 5 of lower-edge routine (3 dots)
75
←feed increment 6 of lower-edge routine (3 dots)
(n + 2)-th feed→ increment (11 dots)
←feed increment 7 of lower-edge routine (3 dots)
70
followed by 3-dot feed increments up to feed increment 15 of lower-edge routine
65
60
(n + 3)-th feed→ increment (11 dots)
recorded with Nos. 1-11 (Nr, Ni and Nh)
recorded solely with Nos. 9-11(Nh)
feed increment 1 of→ transitional routine (3 dots)
55
feed increment 2 of→ transitional routine (3 dots)
feed increment 3 of→ transitional routine (3 dots)
50
feed increment 1 of→ lower-edge routine (3 dots)
45
feed increment 2 of→ lower-edge routine (3 dots)
feed increment 3 of→ lower-edge routine (3 dots)
40

【Fig.21】


sub-scanning direction
feed increment 2 of lower-edge routine (3 dots)
feed increment 3 of lower-edge routine (3 dots)
feed increment 4 of lower-edge routine (3 dots)
intended lower-edge position of paper
feed increment 5 of lower-edge routine (3 dots)
feed increment 6 of lower-edge routine (3 dots)
feed increment 7 of lower-edge routine (3 dots)
feed increment 8 of lower-edge routine (3 dots)
feed increment 9 of lower-edge routine (3 dots)
feed increment 10 of lower-edge routine (3 dots)
feed increment 11 of lower-edge routine (3 dots)
feed increment 12 of lower-edge routine (3 dots)
feed increment 13 of lower-edge routine (3 dots)
feed increment 14 of lower-edge routine (3 dots)
feed increment 15 of lower-edge routine (3 dots)
feed increment 16 of lower-edge routine (3 dots)
printable area
printing area
nonprintable area
No.
45
40
35
30
25
20
15
10
5
1

【Fig.22】



sub-scanning direction
print head
No.
1
5
30
35
40
45
50
55
←feed increment 1 (13 dots)
←feed increment 3 (13 dots)
←feed increment 4 (13 dots)
←feed increment 5 (13 dots)
nonprintable area (36 lines)
printable area

【Fig.23】